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Notes on the construction and equipment of trenches

Army War College (U.S.)

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3. The most conspicuous changes that have resulted in field fortification are:

(*a*) Less extensive field of fire.

(*b*) Greater importance and corresponding greater difficulty of concealment, involving use of screens, dummy trenches, hidden emplacements, and covered approaches.

(*c*) Deeper and narrower trenches.

(*d*) Greater use of traverses and parados in firing trenches.

(*e*) The use of many support and cover trenches generally parallel to the firing trench and not very distant therefrom.

(*f*) More numerous communicating and approach trenches, screened and defiladed, forming with the firing, cover, support, intermediate, and reserve trenches a labyrinth of trench work known as the "first intrenched zone."

(*g*) Increased use of cover.

(*h*) Provision of shelter for men in cover, support, intermediate, and reserve trenches, and in deep underground bombproofs or "cave shelters," safe against powerful artillery fire; less elaborate shelters in the walls of the cover and support trenches and sometimes in the firing trenches.

(*i*) Extensive use of strong points and supporting points in the first intrenched zone.

(*k*) Provision for the defense of the communicating and approach trenches against flank attack by hostile forces that may have broken through the front lines.

(*l*) A second intrenched zone some 2 or 3 miles in rear of the first zone, generally on the reverse slope of a crest or ridge, and connected with the first-zone trenches by sheltered approaches, natural or artificial.

(*m*) Intrenched zones still further to the rear for possible occupancy in case of defeat or retirement.

(*n*) Increased use of obstacles, especially barbed-wire entanglements.

(*o*) Increased use of mines and countermines.

(*p*) Accessory special measures to prevent surprise and to resist special methods of attack.

(*q*) Systematic measures to prevent confusion and going astray of troops moving in the maze of trenches, by day and by night, such as guideposts, lights, maps, names of approaches, and shelters.

(*r*) Routine measures of maintenance, convenience, and comfort due to the long-continued occupancy of the trenches, such as revetment, drainage, heating, food supply, water supply, ammunition supply, and sanitation.

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11. *Assembly points* are former firing trenches which have been organized for a stay of several days, or they are short trench elements dug especially to hold companies during short stays, and in which the men can only sit down. Even the latter should contain water barrels and latrines, also a command post sheltered from rain, where the captain can make a light, open his map, and confer with his platoon leaders.

12. *Strong points and supporting points.*—In every intrenched zone there will be a certain number of points whose loss or occupation by the enemy will endanger seriously the rest of the line or weaken the defender's hold upon it. Other points particularly favorable for defense will also occur. Such points should receive special treatment so as to develop to the utmost their capabilities for defense and to enable the troops to hold them even after the neighboring portions of the line have been lost. If the intervals between these points are great, there should be small intermediate works. These works should be clearly designed to offer a protracted resistance, unsupported if necessary, to hostile attack from any direction, flank and rear as well as front.

The importance of the point to be strengthened, its position, and its nature generally determine the area to be inclosed. A large defended work offers a less concentrated target to hostile guns and is therefore less vulnerable, but it requires a large garrison. It is usually garrisoned by a battalion or regiment and is then called a *supporting point.* (Pls. I, II, and IV are for foreign units with companies of 200 men.)

13. The small intermediate works above referred to are generally arranged for an all-round defense. Such a work is designed to be held by a company or a half company and is called a *strong point.* This type of work should be carefully concealed and strongly constructed, or it will become a shell trap. Good bombproof cover for the garrison should be provided within the work. The garrison should be kept small and the defense provided by machine guns to as great an extent as possible.

14. The larger *supporting points* are better defended by a system of trenches covering a more extended area. The edges of such a center should be provided with defenses against attacks from any direction, these defenses consisting either of a continuous firing trench or of isolated lengths of firing trench covering every possible line of approach and connected with one another and with the works in the interior of the locality by communicating and approach trenches. Small strong points such as are described above might

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there is no danger of firing into the adjacent supporting or strong points.

24. The reason for breaking a front or indenting a line to provide flanking fire, is that a rifleman fires ordinarily at right angles to the crest of his trench or not more than 30° on each side of such direction. Do not count too much on oblique fire, especially to the right oblique, as the latter requires a displacement of the usual position of the soldier.

25. Intrenched zones in rear of the first zone. These may consist of an intrenched zone 2 to 3 miles in rear of the first zone, usually behind a protecting ridge or crest and connected with the first zone by artificial or natural communications that furnish fairly good concealment from the enemy's view and artillery. A *more elaborate defense* may cover a zone in rear 4 to 5 miles deep in which every *point of tactical importance is fortified by supporting points as already described.* Troops occupying these points can break up the attack of a hostile force that may have penetrated the front system, delay the further advance and facilitate counter attack. They also furnish a framework on which by digging trenches connecting the supporting points a new line can be quickly constructed to hold against vigorcus attack.

One or more similar zones may be constructed farther to the rear.

SELECTION OF SITE.

26. The following general rules should be borne in mind:

(*a*) Study the strong and weak points of the position and locate the line of the firing trench with due regard to the tactical requirements and the economy of men.

(*b*)The field of fire should be such as to expose an attacking enemy to the fire of the defenders in the last 200 or 300 yards of their advance. To insure this the foreground may require clearing. The experience of the present war indicates that the above width of the exposed foreground is ample and even a narrower belt is often considered sufficient with trained troops, provided it is clearly commanded from the firing points and is strengthened by a good obstacle which should also be well screened from the distant view of the enemy.

(*c*) concealment of the works and dispositions is of the greatest importance.

(*d*) The defenders should be screened from the enemy's view and sheltered from his fire by natural or artificial cover so arranged as to afford the maxim development of rifle fire.

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(*e*) The foreground should have obstacles to detain the attacking troops under fire and to break up their formations, but these obstacles should not afford cover for the attacker.

(*f*) Good communications should be provided within the position and over ground that may be used for counter attacks.

27. *First step.*—The first step in the preparations is to improve the field of fire, both by clearing the foreground and by taking ranges to all prominent objects. Special range marks may also be placed if time is available, and the troops should become familiar with features in front and their ranges.

Objects in or near the position that might assist the enemy in estimating ranges should be removed or altered in appearance, so as to make them less conspicuous.

The line of trenches should not be placed too near unalterable features that reveal the position of the lines or furnish good range marks for the enemy.

The stronger points in the line, that is, those more readily defended, may be villages, solid buildings, patches of timber, hills, knolls, or broken ground. These should be specially prepared for defense, as described hereafter.

28. *Firing trenches.*—The firing trenches constitute the principal defense of a position, and they are laid out in irregular lines or in groups, with intervals, according to the character of the ground. The increased importance of screening defense works from view and fire of the enemy's artillery tends to the selection of sites for firing trenches behind rather than in front of the crest of a slight ridge, provided a sufficiently clear field of fire can be obtained against hostile infantry advancing in force. The main advantage of this retired position is that it affords greater security against hostile artillery fire. It must be remembered, however, that security against artillery fire is almost entirely at the present time a matter of concealment; that is, security against observation. If the enemy has hilltops in his possession or can establish an artillery observer with telescope and telephone on high ground from which he can overlook the ridge or crest in front of our trenches, the back or retired position of the firing trench loses much of its advantage. Location of trenches in rear of crest lines should therefore include as an important circumstance the denial of dominating ground to the enemy.

Trenches on the crest or forward slope are certainly exposed to view and bombardment, but the occupation of high ground gives a feeling of superiority to the troops and acts favorably on their morale.

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The forward position has also the advantage, if not too far down the slope, that the support and communicating trenches and the works in which most of the garrison live are fairly well concealed behind the crest. In offensive action the forward position offers greater facilities for observation and for the assembly of troops for the assault close to the front line and unobserved.

Special conditions may justify the deliberate choice of the retired position behind the crest. If adopted, arrangements must be made to deny the enemy access to the crest of the hill and to secure it for ourselves. The firing trench must not be too far down the reverse slope; 50 to 100 yards from the crest line will usually be far enough and gives a sufficient field of fire if machine guns are numerous and well located, and there must be an ample number of saps forward to the top to allow of continuous observation of the forward slope. With these precautions and readiness to deliver an immediate and vigorous counter attack on the enemy if he appears on the crest, the retired position may sometimes be taken up when conditions impose a temporarily defensive attitude and local superiority in artillery is with the enemy. But if the two lines remain facing each other on the same ground for a protracted period it will be impossible to prevent the enemy from ultimately establishing himself on the crest unless it is included in our line. The location selected should be such as to conceal and shelter the defender's reserves and communications.

29. The soldier, in attack, first learns to make use of existing cover and then to improve same when there is time. Where he has to advance over ground devoid of cover and is halted by the enemy's fire he will have to make for himself individual cover as rapidly as possible, using his intrenching tool. With this he may make a shallow rifle pit in which he can lie, the earth thrown up in front protecting his head and shoulders while firing.

If compelled to hold the line where he has been halted, he may improve this rifle pit to a kneeling, sitting, or standing trench. These individual shelters may be then connected and finally an intrenched zone develops from the first series of simple pits. Some of the first positions in the western Europe arena were thus occupied, and by successive efforts of each side to get better ground they were gradually altered until an equilibrium was fairly established and the more permanent lines elaborated.

The location is often determined under these circumstances by the line at which the troops are forced to halt by the enemy's fire and to dig themselves in.

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most effective employment of machine guns. Such a trace will expose short lengths of trench to enfilade fire, but the effect can be reduced by proper traverses. The enemy's line will also be in salients and reentrants and will be equally exposed to enfilade from our side.

Minor irregularity of trace is essential and should always be obtained. The creation of large salients to include an important tactical point will depend upon the following important conditions:

(*a*) Whether the possession of the point in question by us will facilitate future offensive action without unduly weakening our line.

(*b*) Whether its possession by the enemy will seriously threaten the security of our trenches.

32. The permissible traces for communicating and approach trenches are the indented line, easy to dispute in case of attack, and the zigzag, which gives better defilade. The litters evacuating wounded move more readily in the latter trace.

The best type is the winding one, but the curves must be sufficiently pronounced to give real protection against enfilade fire. If traverses are used in communicating and approach trenches the best kind is the island traverse with the trench going round it on both sides.

33. *Concealment.*—Aerial reconnaissance makes concealment of a position impossible, but isolated works and gun emplacements can be hidden and trenches in woods may escape observation if clearing is not overdone. Airplane photographs show clearly every trench and traverse in open country and even wire entanglements. Nevertheless every effort should be made to make the work inconspicuous, to deceive the observers by dummy trenches, to avoid paths or tracks that call attention to works otherwise well hidden, and to avoid the construction of fresh trenches immediately before an attack which would reveal the fact that an attack was intended. Work done on buildings themselves is easily concealed from air observers, but the existence of trenches around or leading to a building gives a clear indication of its occupation.

34. *Buildings.*—Substantial buildings found close to the line of defense may be demolished or they may be occupied. The decision depends generally on two points, whether they have cellars which can be improved into good cover and whether it is possible to demolish them. Buildings draw artillery fire and unless good cover can be constructed in connection with them they are nothing but shell traps. Solid blocks of buildings with cellars can be made into good

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cover as a rule and had better be occupied. A building without cellars may be left out of the line if it can be so effectively demolished as to afford no cover to the enemy.

35. *Woods.*—A position from 30 to 50 yards inside the edge of the wood will afford concealment from observation and accurate artillery fire and will deny the edge of the wood to the enemy. The front edge should under no circumstances be occupied as it furnishes an excellent range mark for the hostile artillery. (Differs from par. 23, Part V, E. F. M.)

If a wood has to be left unoccupied in the immediate front of an intrenched line special arrangements must be made for the concentration of fire on the near edge of the wood and on the ground between it and the front trench.

PROFILES.

36. A narrow trench is desirable as it presents a smaller target. There must, however, be enough width to permit the construction of a firing banquette and of a certain deeper space at the rear part of the trench to allow men to pass behind the firing line. Also enough slope must be given the walls and the embankment work to prevent crumbling.

Unrevetted trenches even with side slopes as flat as 1 on 1 are sure to cave in. A good berm 12 inches wide and revetment are therefore essential. The minimum width at the bottom is 2 feet 6 inches, or better 3 feet, but 3 feet should seldom be exceeded; greater width reduces the protection too much. Revetted sides should have a slope of 4 on 1 or 3 on 1 and not be cut vertical. The depth from the top of the parapet to the floor board or bottom of the trench should be not less than 7 feet if possible. Height of parapet will depend on the site and the depth of the ditches for drainage.

37. *Firing trenches.*—The figures given on plate III are typical sections such as can be excavated in good soil when time is available. In actual practice they will be rougher and more irregular, with slopes depending on the consistency of the soil and the time at the disposal of the troops, but an effort should always be made to follow the prescribed lines of excavation as accurately as possible. Smooth and even slopes and crests of visible earth embankments and parapets should be avoided. Rough sod, grass, bushes or clods of earth should be used to break the continuity of straight lines and to make them merge into the surrounding features. It will be noted that the firing banquette is 5 feet below the interior crest instead of 4½ feet as given in the Engineer Field Manual and Field Service Regulations with the idea that the men who occupy them will build up the

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banquette or notch or loophole the parapet when they take position in them.

It is both an advantage and a standing rule that if done by military labor, riflemen should themselves construct the trenches they are to hold.

The best type appears to be a trench with a firing banquette, for five or six rifles in each bay, between two traverses each 6 feet thick, and with the back part of the excavation formed into a communicating trench for observation and manning of parapets. This trench is somewhat deeper and 3 feet 3 inches wide.

Another type of firing trench has a minimum width of 28 inches, in order to afford the firer better protection; 15 to 20 yards in rear there is a second trench which permits communication and contains the shelters. The essential point in training is that one of these types should be adopted as the normal type suited to the local conditions, and the troops should be thoroughly trained in its construction.

38. Every firing trench should fulfill the following essential conditions:

(*a*) The parapet must be bullet proof.

(*b*) Every man must be able to fire over the parapet with proper effect; that is, so he can hit the bottom of his own wire entanglement.

(*c*) Traverses must be adequate.

(*d*) A parados must be provided to give protection against the back blast of high-explosive shell.

(*e*) The trace of the trench should be irregular to provide flanking fire.

(*f*) And if the trench is to be held for any length of time, the sides must be revetted and the bottom of the trench must be floored and drained.

The narrower the trench the better the cover, but if too narrow it may hamper the movement of troops too much. Therefore, a firing trench is usually made broad enough to allow of movement behind the line of men manning the parapet. Every man must be able to use his rifle over the parapet, and the men moving behind must not have to stoop down low in order to get their heads under cover.

The resulting section is, therefore, with a banquette or firing step 18 inches wide and 4 feet 6 inches (or 5 feet if we allow for a small notch or hollow to hold the rifle) below the crest of the parapet, and behind this a deeper portion from 18 to 30 inches wide at the

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40. Earthworks built entirely or largely above ground are used only when wet, ill drained, or rocky ground compels. They afford good cover and if the parapets are about 10 feet thick at the top, with gentle front slope, and have had time to consolidate and dry out, they are said not to suffer much more from heavy artillery bombardment than do the usual types of trenches with low parapets.

They are, however, very conspicuous, especially when new, and require great time and labor to build. They are much more comfortable for the troops sheltered behind them. The ditch excavation in front may be used as an obstacle and filled with wire. There should be at least a 2-foot berm at the foot of the exterior slope so that this is not likely to fall into the ditch. Parapets of sandbags exclusively are much more vulnerable than those of earth, and are of expensive material; they should be avoided except for minor works, such as blocking a trench toward the enemy, barricading a road and the like. They may be used in emergency in the first zone if haste or silence is paramount importance.

TRAVERSES.

41. Traverses are solid masses of earth extending from the front wall of the firing trench or sometimes from the rear wall dividing the trench into a series of compartments whose purpose is to decrease the exposure of the men to enfilade fire and to localize the effect of a shell bursting in the trench. Traverses must be strong and solid and when possible should consist of the undisturbed earth. They should be from 2 to 4 yards thick and should overlap the width of the trench by at least 1 yard, and should be well revetted. The clear distance between traverses is that necessary to accommodate a small number of rifles, say those of a squad of 5 to 8 men; the distance therefore is from 5 to 8 yards. (Pl. III.)

Traverses in a trench facilitate bombing attacks along its length by an enemy who may have entered it as grenades can be thrown from under cover of a traverse into the second compartment beyond. A longer compartment to prevent this may be occasionally placed in the line of the trench. This long bay should be straight, and the traverses on either end should be loopholed for fire into it. Bombing trenches or pits behind the front line are also useful to stop this form of attack.

Where traverses have to be built in a completed trench insufficiently traversed, they must be made in embankment using the earth excavated to form the passage round the traverse and supplementing it with sandbags or other revetting material.

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42. For approach trenches the best type is the "*island traverse*" with the trench going round it on both sides. Sections of trench subject to special exposure are sometimes protected with "bridge traverses," built across the top of the trench on supports of timber or steel. (Pl. III.)

HEAD COVER.

43. *Head cover* is the term applied to any horizontal cover which may be provided above the plane of fire. It is obtained by notching or loopholing the top of the parapet.

Notches.—When the relief of the trench is too great for a man to fire standing, or when the height of the parapet is more than 1 foot above the level of the ground, notches should be made in the parapet. The simplest way to make these and give support to their sides and make them the least visible is to arrange sand bags on top of the parapet.

Loopholes.—When overhead cover is used, loopholes are necessary. They may be collective or individual (Pl. III), constructed of sandbags, wood, steel, hurdles, or other material. They should be concealed by using grass, brush, canvas, or empty sandbags. The sky as a background should be avoided by raising the parados or placing a canvas curtain behind them, and closing the opening with a metal cover which can be removed when the loophole is in use.

In addition to their visibility, loopholes have the disadvantage that they cause a pause in the fire of the defender when the attack reaches the most deadly zones of fire, because the defenders have to withdraw their rifles to prepare for bayonet fighting. It is therefore necessary to arrange for fire over the parapet. For this purpose banquettes can be constructed of sod, stones, logs, or scaffolding between the loopholes. In all firing trenches, however, a few loopholes are desirable for the use of snipers, and there may be one or two between each two traverses. All night firing is over the parapet.

In some sectors the loopholes should have their axes inclined to the normal to secure flanking fire. Every loophole intended for observation should be placed obliquely in the parapet in order to be protected against shots from the front. The bottom of a loophole must be in the plane of fire that sweeps the ground in front.

OVERHEAD COVER.

44. The defenders of a trench must have shelter against bombardment by high-explosive shells and against the weather.

This is secured by traverse, narrow trenches, and shelters. (Pl. III.) Shelters are classified as splinter proofs of bombproofs accord-

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ing as they are designed to afford protection against the splinters of shells burst over or near them or against shells hitting them direct and bursting on impact. Distinction between the two is important.

45. Shelters in the front wall of the firing trench under the parapet made by undercutting are objectionable. Even if carefully shored up they weaken the resistance to the burst of a high-explosive shell. A certain amount of splinter-proof cover should be provided in the front line, and it will also serve as protection against the weather. The best place for it is in the walls of the cover trench. It may also be placed behind the parados.

46. Bombproof shelters safe against heavy high-explosive shell have to be dug very deep and entered by a narrow opening and steps. This means delay for the men in getting out of the bombproof, and every moment is important in a well-planned attack, as the enemy will make a sudden assault almost at the moment the artillery lifts its range. Deep cover shelters are therefore inadmissible in the front line except for the protection of machine guns (for which special lifts may be provided) and their detachments and for company command posts. They are also dangerous in an attack by gas. They are generally confined to the position of the battalion reserves and to the strong points that may form a part of the front system. They may be used elsewhere, however, if the soil and natural features are favorable to their construction and arrangements can be made to get the men out of them quickly.

The entrances must be covered to keep out splinters. They are, therefore, masked either by a turn in the approach trench or by a traverse or splinter proof of gabions or sand bags. Each shelter should be provided with two entrances, of which one may consist of a simple exit without head cover, with a little stairway to be used in case the main entrance is obstructed.

The shelters which are generally large enough for 25 men at most should be constructed so that they will contain the men not on guard, half of them seated and half of them lying down.

The roof may be built as follows: First a layer of poles 6 to 8 inches thick, then a layer of earth 8 to 12 inches thick, a second layer of poles at right angles to the first, then a second layer of earth 12 inches thick.

The water-tightness of the roof is secured by sheets of corrugated iron on the top layer of poles or by tar paper placed on the surface of the earth, in which case the ground should be well tamped. It is well to place brush or straw between the sheet iron and the earth above, also to place branches on the first layer of poles.

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Roof timbers must always have *three* or *four* times the strength necessary to support merely the load due to the thickness of the roof. This allows for the shock of the shell as well as for the contingency that a new garrison may pile 2 or 3 feet more of earth on top of the existing roof.

A rectangular timber will support more weight if set on its edge than if set flat.

The ends of timber should never be supported on sandbag walls or even direct on solid ground. A strong timber frame should always be used on two opposite sides of the shelter to support the ends of roof timbers.

A "burster" layer of 6 inches to 12 inches of brick or stone should always be provided near the top surface of the roof. Over this burster layer should be a layer of not less than 6 inches of earth to decrease danger from the scattering of the stone or brick by the burst of the shell. As the object of the burster layer is to explode the shell near the surface, it will be to a large extent defeated if the layer of earth above it is made more than 12 inches thick.

Cave shelters must be ventilated and the ventilator may be utilized for a periscope.

Splinter-proof cover is afforded by a layer of logs or beams 6 inches or more in depth covered over with not less than 12 inches of earth. (Differs from par. 14, Part V, E. F. M.) The following forms a roof proof against a 6-inch high-explosive shell: A layer of rails or beams, 18 inches of earth, a layer of brick, 2½ feet of earth, another layer of brick 6 to 12 inches thick, and over all 6 inches of earth.

REVETMENTS.

50. The deep firing, cover, support, reserve, communicating, and approach trenches now considered necessary require careful consideration of suitable revetments, especially where the soil does not weather well. To keep the men comfortable and the trenches clean and dry requires something more substantial than the usual temporary revetment, such as brush, sod, and sandbags. Some soils are apparently firm and stand at a steep slope when first excavated, but under the action of the weather the side walls soon slough off, obstruct the trenches, and make them muddy in rainy weather. In case of long continued occupancy of the trenches, revetments of timber and plank will gradually replace the lighter forms, and boards and gratings will be used to floor the bottom of the trenches.

In regions near cement mills and where gravel, sand, ruined walls and houses, or other suitable materials can be found, concrete blocks

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or concrete molded in place may be used for revetments and for flooring the trenches.

A convenient size of side wall blocks is 10 by 8 inches by 6 inches thick, and for floor blocks 30 by 20 inches by 4 inches thick. Side-wall blocks should have two projecting wire loops to serve as handles in carrying the blocks through the trenches and in anchoring them in place. These blocks afford a neat and substantial revetment which contributes materially to cleanliness. They are also useful for building small covered observation stations along the parapets.

51. Some of the forms of temporary revetments are:

Sandbag.
Brushwood hurdle.
Wire-netting hurdle.
Continuous hurdle work.
Expanded metal.
Rabbit wire.

52. *Sandbags* are laid as headers; i. e., the length of the bag at right angles to the face of the revetment or as stretchers; i. e., the length of the bag in the plane of the face of the revetment. The revetment should slope at an angle of 4 to 1, and therefore the ground on which the bottom layer or course is laid should be at a slope of 1 to 4. The sandbages must be bonded, i. e., the bags of each course must break joint with the bags of the courses above and below. A certain number of headers must be used to tie the revetment into the bank. It is usual to lay sandbags with one header to every two stretchers.

When filling sandbags the bottom corners must be well tucked in and it helps if the mouth of the bag is turned over for about 3 inches. The bag then stays open more easily. Bags should be three-fourths filled and care must be taken to obtain uniformity in this, for unless the bags are all the same size they will not build up readily. A sandbag when filled should measure 20 by 10 by 5 inches.

The line of revetment must be prepared by digging a notch with the bottom at a slope of 1 to 4 and broad enough to take a header. Since the header is 20 inches long the back of the notch should be 5 inches below the front. If the face of the revetment is kept at right angles to the bottom of this notch the required slope of 4 to 1 will be obtained.

In laying the bags the mouths of the bag should be folded over underneath the bags. The mouths of the headers and the seams of the stretchers should be turned in toward the back so that if the bag becomes untied or the seams burst the earth will not fall into the

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trench. The bags should be beaten with a spade, maul, or shovel into a rectangular shape, otherwise the bags do not get a firm seating. The face of the revetment should be quite smooth and not lumpy. Unless it is certain that the revetment is not to be extended, the ends should be left irregular so that any extension will be bonded to the existing revetment. It is best to finish off the parapet of a firing trench with a row of headers.

53. *Brushwood hurdles* are usually made 6 feet long and of the required height. The pickets should project 18 inches below the brushwood and be sharpened for driving into the ground. They should be about 3 inches in diameter and should be spaced approximately 2 feet apart; that is, four pickets to a hurdle. Actually the two outer pickets should be about 6 inches from the ends of the hurdle. The pickets are therefore 1 foot 8 inches apart. The brushwood should be 1 inch to 1½ inches in diameter and of ash, willow, or other pliable wood.

To construct the hurdle, drive the pickets into the ground firmly, and 18 inches from the bottom of the pickets run two strands of plain wire along the pickets, taking a turn round each picket. Twist these wires together until they are quite tight, then weave the brushwood in and out of the pickets, beginning at the bottom and keeping it pressed firmly down on the wire. Each length of brushwood should pass alternately in front of and behind the pickets and if a piece of brushwood is behind the picket the piece next on top should be in front of it, and so on. If the brushwood is not long enough to reach the length of the hurdle, twist another piece to it or tie a piece to it with wire. It is seldom possible to bend a piece of brushwood round the end picket and take it back along the hurdle, so let it project about 6 inches and cut it off. Continue until half way up, then put in a couple of strands of wire twisted as before. Complete the hurdle and finish in the same way with wire along the top. Then sew the hurdle in three or four places from top to bottom with plain wire. This construction differs from that mentioned in paragraphs 30 and 31, Part V, E. F. M.

In placing the hurdle, the bank should be cut away to a slope a little flatter than 4 to 1. The hurdle should be laid against the bank and the pickets driven into the ground 18 inches. The top of each picket should be anchored back by 6 to 8 strands of plain wire to a stout anchor picket driven firmly at a good slant. The anchor picket should be about 3 feet long and driven in 2 feet. It should never be less than 10 feet from the revetment even in good ground, and may be as much as 30 feet away in bad holding ground.

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starting and finishing 9 inches from the edge of the metal, thus leaving a length of 9 inches at each end of each pole not attached to the metal. The panel can then be rolled up and carried into the trench.

To construct the revetment, cut the bank back to a slope of 4 to 1. Lay the panel against the bank, the poles horizontal, the panels overlapping; that is, the edge of the metal of one panel is slipped in between the poles and metal of the next panel. The poles will then overlap 9 inches and the metal will overlap 9 inches behind them. Take good 8-foot pickets 4 inches in diameter and drive them on a slope of 4 to 1 tight against the panels, one at each overlap and one between the overlaps. Anchor back in the usual way.

In getting round traverses the horizontal poles must be omitted and the panels cut vertically from the top about three-fourths of the way down. One-half is then allowed to slide behind the other, thus keeping the slope of 4 to 1.

57. *Continuous rabbit-wire revetment.*—Use slightly lighter pickets 2½ to 3 inches in diameter. Cut the bank back to 4 to 1. At intervals of 2 feet or 2 feet 6 inches, cut vertical grooves in the bank big enough to take a picket. Drive a picket with its foot in the bottom of each groove. Do not drive in more than 6 inches and let the picket stand a few inches clear of the bank.

Then at the bottom, half way up and about 6 inches below the top of each picket, run two or three strands of plain wire, twisted up taut. The bottom strands should be put on first, then the middle, then the top, so as to avoid loosening the wires already put on by overtwisting the next ones. Then run diagonals of similarly twisted wire from the top of each picket to the bottoms of the pickets on both sides. Where the diagonals and horizontal wires cross in the middle of the panels, join them together with a short piece of plain wire. This gives a framework to hold the rabbit wire.

Run the rabbit wire behind the framework; that is, between the framework and the bank. Pull it as tight as possible and attach it to the framework in many places with short lengths of plain wire. Put on the anchor wires and draw the poles up against the bank. Then drive the poles tight home. Tighten up the anchor wires so as to draw the poles into the grooves. The rabbit wire is then brought tight against the bank.

Angle irons may be used for anchor pickets. Anchor pickets and wires should be buried.

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DRAINAGE.

58. *Drainage* is essential to the preservation of the trenches and the health and comfort of the troops. In deliberate works it is well to study the drainage question in detail and to dig special ditches of ample capacity before work on the trenches proper is begun. Of course this can not be done in the presence of the enemy. About the only remedy in that case is the collection of water into pits, the use of constant pumping, and the construction of floors or gratings. The bottom of the trench should slope toward the back, where the water may be run to a pit in a drain. Where the soil is impermeable an endeavor should be made to reach a permeable layer by boring with an earth auger. In hilly terrain the water may be drained off by pipes placed under the parapet. (Pl. III.) If a permeable layer can not be reached, the drainage pits must be emptied with buckets or pumps.

59. The drainage and flooring of *approach and communicating* trenches constantly used is specially important, and should be considered in their location. When timber for flooring is not available, drains filled with broken stone should be constructed in the bottom of the trench. A good form of floor grating is in lengths of 6 feet, 18 to 24 inches wide, made of cross pieces of ¾ by 4 inch boards nailed to two longitudinal pieces of timber about 3 by 4 inches set on edge.

60. In *shelters* provision should be made for the drainage of water which runs through the entrance or seeps through the walls. A drainage pit should be constructed near the entrance and the floor of the shelter should be sloped toward it; the pit must be emptied when necessary. (Pl. III.) The roofs of shelters should be made waterproof by using roofing paper, corrugated iron, tin or zinc, linoleum, canvas or tiles.

LATRINES.

61. *Latrine* accommodation should be ample; seats should be based on at least 2 per cent of the troops using them. Urine receptacles should be based on the same scale. The best location for latrines and urinals for the firing line is behind the cover trench in T-heads at the end of short branches leading off from it. (Pl. III.) Latrines should be provided for all trenches and shelters which have to be occupied even for short periods by troops.

62. The following are some of the various kinds:

(*a*) Deep trench with box on top or "box latrine."

(*b*) Buckets.

(*c*) Short trench system.

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Box latrine.—This consists of a pit 15 feet long by 2 feet wide by 6 feet deep. A square box or boxes are placed on top. The sides should be boarded all round so that the boards project over the sides of the pit. The height of the box should be 17 inches. Two holes are made in it and a lid provided. If deep enough it does not smell. It is most suitable for trenches, provided the ground is dry. Box latrines are not suitable for positions that are to be occupied a long time.

If there are frequent approach trenches, say one every 100 yards, a good position is just off the approach trench. This may not be suitable, depending on the trench; in some cases a suitable site is at the corner of a traverse.

Bucket system.—If the ground is wet and deep trenches can not be dug, the bucket system is most suitable for trenches. Any metal receptacle will act as a bucket. The excreta must be covered with earth. It is very important that every officer, noncommissioned officer, and man shall make it a habit to cover the excreta every time before he leaves the latrines. Officers and men are apt to forget this and in five minutes excreta will be covered with flies. The buckets are removed and emptied at night. They should be emptied into a deep pit somewhat in rear of the support trenches. This pit should be covered, screened from flies, and burned out at intervals.

The short trench system is suitable only on the line of march when a halt is made for a night or two. These should be dug 3 feet long by 2 feet wide by 1 foot deep with 4 feet 6 inches interval between latrines, so that when the first lot are full and covered in, fresh ones can be dug between, leaving a margin of 9 inches on each side of the hole of solid and not foul ground.

Every latrine should have a separate pit dug for a urinal. The following are the various kinds:

(1) *Pit with tin can on top.*—The purpose will be served by any pit 3 feet deep and 3 feet in diameter, with stones in the bottom, covered over with a tin can perforated at its bottom placed on the stones.

(2) *Trough system.*—This is more elaborate and suitable for a permanent camp. A trough slightly inclined, 2 feet long, made of wood lined with zinc. Oil can at one end out on the ground, placed to catch flow from the trough.

(3) *Pipe system.*—This consists simply of an oil can, with a pipe soldered on, conducting the flow to a pit 3 feet deep. This is clean and simple.

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Starting 6 yards behind C comes party D, which works on the same system as B and puts on the diagonal, keeping behind its own wire. Care must be taken to make real round turns.

Party E runs out the first loose wire, starting about 12 yards behind D. One man holds the coil and unwinds it. One man places the wire in position on the diagonal. The third man clips the loose wire to the diagonal.

Party F comes 15 yards behind E and runs out the second straight wire. Party G drives the third row of pickets, measuring the position of each from those of the second row. Party H starts 6 yards behind G and puts on the second diagonal. Party I starts 12 yards behind H and runs the second loose wire. Party K starts 15 yards behind I and completes the bay with the third straight wire.

The direction is kept by the men of the left file who provide themselves with a piece of string or tape, equal in length to the distance from the parapet to the front edge of the wire. They go out with party A. One man places himself at the foot of the parapet with one end of the string in his hand. The other runs the string out until it is taut. The man on the parapet keeps the string always perpendicular to the general line of the parapet. The other man keeps it taut and moves along with party A. Work can be done with parties of two men, but if one is hit the work is disorganized.

If there are fewer parties the same party may have to do two or more parts of the work. Thus if there are only six parties A will also do G's work, B will do H's, C will do I's, D will do K's. The pickets must be driven in far enough in the first instance. If they have to be driven after the wire is on, the wire will be too low. Mauls should be muffled with sandbags nailed on.

Advantages of this form of obstacle.—Easily thickened; quick to build; easy to conceal; not easily destroyed by hostile fire or by friendly fire which will pass over it; the men are always behind the wire; easy to mend. This entanglement requires one picket and 11 yards of barbed wire for each yard of front.

67. The high wire entanglement is similar in a general way to the low entanglement, but is 4 to 6 feet in height. It usually consists of three to five rows of stakes connected by barbed wire. In addition to the horizontal wires connecting the tops of the stakes it has diagonal wires running from the top of each stake to the bottoms of all adjacent stakes. The side toward the enemy should be completed as an ordinary wire fence. Slight irregularities in height of stakes and arrangement of wires add to the value of the obstacle.

68. *French wire.*—This consists of a continuous spiral of plain wire 3 feet 6 inches in diameter, each turn of wire being clipped to the

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turns on both sides in five places. When closed up it looks very much like a coil of plain wire, but when pulled out it makes a cylinder of wire mesh. Each small coil pulls out to a length of 20 yards. A big coil consists of five small coils.

Advantages and disadvantages.—It can be easily crushed down by throwing a weight on the top and must therefore be supported by pickets and barbed wire. It is easily carried and quickly put up. It is held in place by iron staples 5 inches long. The number of men required for a party is 26. Two men keep the direction with a string as for low wire and the remaining 24 are divided into parties of 3 as for low wire.

Description of obstacle.—The obstacle consists of two rows of French wire. Each small coil is stapled down in five places, that is at each end, one-fourth, one-half, and three-fourths of the way along. Where two coils meet the same staple fastens down both coils.

Pickets 5 feet long are driven into the center of the coils in five places as for the staples. These pickets should be driven in at least a foot. A strand of barbed wire is run along the top of each row of French wire. These strands of barbed wire are pulled as taut as possible and are twisted on the French wire with a staple, peg, or pair of wire cutters, close to each picket and in several places between the pickets. This barbed wire supports the French wire.

The two rows of French wire are tied together by a diagonal strand of barbed wire running from the tops of the pickets of one row to the tops of the pickets of the other row.

In addition a strand of barbed wire is run along the front of the front row of French wire and twisted to it. This is partly to hold up people trying to crawl through and partly to hold the French wire together, should it come loose from its fastenings. This wire is usually called the "apron wire."

After this more apron wire can be added or loose wires may be inserted between the two rows. The two rows of French wire are just far enough apart for a man to pass between them.

Duties of wiring party.—Party A, first French wiring party.

A 1 holds end of wire and staples it down.

A 2 pulls wire out for 20 yards.

A 3 shakes wire clear of obstructions and puts in staples one-fourth, one-half, and three-fourths way along.

A 1 gets another coil and butts it against A 2's end of the first coil and staples both ends together.

A 2 and A 3 proceed as before and so on until the first row is complete. A 1, 2, and 3 carry 15 to 20 staples slung on a cord over the shoulder. As soon as party A is clear, party B comes out.

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be screwed into a firm hold without noise. When the enemy is too close for this, various forms of portable obstacles in the nature of chevaux de frise are employed. These are made up at the depots, brought forward through the trenches and simply tossed out in front, by day or by night.

Several forms are used, such as the regular chevaux de frise, the elongated sawbuck, and the tripod or hollow cube formed of steel angle rods or plain rods. These obstacles are covered with barbed wire. Boards filled with nails are also used.

71. When the enemy's bombers get into the approach trenches they attempt to work down then under cover of the zigzags, curves, or traverses to attack one of the rear lines and provision should be made by the defense to check such advance. It is best accomplished by making the rear 40 yards of any approach trench straight and providing for machine gun and rifle fire down the straight portion. An alternative arrangement is to provide enfilade fire down one or more of the zigzags from loopholes in the parapet of a trench in rear cutting the necessary sloping channels to fire through. Provision must also be made for blocking the rearmost 40 yards of the approach trench at both ends of the stretch by means of movable obstacles, such as chevaux de frise or other forms mentioned above, kept in a corner of the trench whence they can be readily pulled down into position by the last man to retire.

72. Openings for the passage of troops through wire entanglements are generally about 10 yards wide and are placed so that two belts of wire overlap the openings. (Pls. I, II, and IV.) The continuity of the obstacle may be preserved by using gates or barriers that can be quickly opened and closed.

The best place for the openings is at the flanks of the supporting points between the wire entanglements around the supporting points, and those in the intervals. If these openings must be placed in the intervals on account of the terrain, they must be covered by the close fire of sections of trench placed immediately in rear.

DEFENSE OF BUILDINGS.

73. It is often advisable to include substantial buildings in the firing line. Experience shows it to be very hard to dislodge a determined defender from a properly organized building. On the other hand, buildings in or near the front invariably draw much artillery fire. For this reason a building should not normally be occupied by day unless it has cellars which can be improved to provide good bombproof cover, or similar cover can be made quite

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close to the house and connected with it by communicating approach trenches. Otherwise if the building has been put into a state of defense a garrison should be detailed which will occupy it only at the last moment in case of attack. A building is strongest for defense when it has been knocked about a bit. The defensive arrangements should be concentrated on the first floor and cellars; time spent on the upper stories is sure to be wasted. In the building itself the work to be done is:

(*a*) Reinforce the cellar roof if possible with concrete; it must be well shored up to enable it to carry the extra protection and also the débris which subsequent shelling will bring down upon it.

(*b*) Loophole the walls for rifle or machine gun fire; the nearer the loopholes are to the ground the better the protection afforded, but there is a risk of falling débris blocking them.

(*c*) Thicken walls up to the height of the loopholes. This thickening may be done by throwing earth up against the outside of the building, or making a wall of gabions filled with earth or of earth between hurdles, 3 feet clear of the wall of the building to serve as a shell burster. Building up inside with brick rubble or earth in sandbags is better, as loopholes near the ground level and cellar windows for machine guns can then be used.

(*d*) Block up and loophole ground floor doors and windows.

(*e*) Erect overhead cover over firing positions. This should be in the form of a false roof, preferably of concrete, otherwise of heavy rails or very stout timbers on very substantial timber supports or on rails and girders. This roof will protect the firers from falling débris, and the more the house is knocked about the stronger will the cover become.

In connection with the defense of the building there may also be firing trenches in front of it and on either flank, communicating by trenches with one another and with the building, the whole forming practically a small strong point of which the house is the keep. "Slit" trenches situated close behind the house and connected with it by an approach trench form a useful adjunct to the defensive arrangements.

CONSTRUCTION OF TRENCHES.

74. *Under fire.*—The first object is to get some sort of cover as quickly as possible for the firing line. The individual men start to dig pits for themselves just where they are stopped by the enemy's fire. As soon as may be these pits are then joined to form a continuous firing trench. This trench may form the ultimate front firing trench and the cover trench be subsequently dug back of it,

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or it may become the cover trench and new firing trenches may be dug in front by pushing forward at intervals. The question of proper traverses for the final trench should be considered in the spacing of the first constructed pits and in joining them up to form a trench. It is desirable to have traverses formed out of the original undisturbed ground.

If the first dug trench is to form the cover trench the next step after completing it is to push forward T-heads to the front to form the firing bays.

The work of digging the individual firing pits will be begun by the infantry troops generally with their intrenching tools. Troops should, therefore, be well practiced in digging themselves in by night or day with these tools.

Heavier more effective tools should be brought up to the firing line as soon as possible and every plan for an advance should provide for a certain number of digging tools in addition to the intrenching tools accompanying the attack, and this number should be supplemented as early as possible by every pick and shovel available.

It may be necessary to wait until dark before a large number of tools can be brought up and serious work attempted, but it is sometimes possible under the covering fire of artillery to dig a continuous trench by day. In any case every effort must be made to get good trenches dug as soon as possible and one of the first things to do is to get some wire entanglement in front of the trench, as this gives a feeling of security to the workers.

During the first day or two the new line will be bombarded heavily and probably counter attacked. If the front trench is constructed in the first instance very close to the enemy's line it is particularly vulnerable to counter attack, and if the enemy succeeds in breaking through the line at a time when there are no defenses prepared behind it he may force a retirement on a large front. The construction of support trenches 100 to 200 yards in rear of the front line and of reserve trenches should therefore be proceeded with simultaneously.

75. *At night.*—If the offensive open attack has to be given up temporarily and the enemy is found in a prepared fortified line a more gradual and concealed method of approach has to be adopted. A line of trenches is constructed in the first place at quite a distance, say 500 to 600 yards or even more, from the enemy's front trench, the exact distance depending on the ground and the facilities for cover. This line is made fairly strong and complete before any further advance is attempted. Then under cover of darkness or fog and perhaps of a heavy bombardment of the enemy's front line a new trench is constructed at a distance of 200 to 300 yards from the enemy.

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78. *Placing the workers and executing the work.*—The men are divided into working groups composed of those who are to work at a common task. Group tasks are laid off at such intervals up to 5 feet as may be determined by conditions affecting the work as time available, tools, character of the work and the soil. In easy ground one pick to two shovels should be furnished; in hard ground one pick to one shovel.

Distribution of tools.—The picks are placed in one pile and the shovels in two piles if there are three men to the group; picks in one pile and shovels in one pile if there are two men per group. The men formed in two or three ranks march by these piles. All those of the same rank each take a tool from the same pile.

79. Mark out the direction of the trench by means of tape or withes, or of markers sitting or lying down indicating points where the direction changes, and where ground should be left unchanged for traverses. The column of workers in single file, groups formed together, arrives at one end of the trace and deploys along the line established by the markers at proper intervals. For special work, splinter proofs and traverses the width of task for a group is proportionately reduced.

Begin work by digging downward so as to cover oneself from the front as rapidly as possible. Commence the parapet in such a way as to make rapidly a mask with a steep slope on the side of the workers. Work under fire is done at night. The men must keep absolute silence, lie down immediately on the ground when rockets appear, and resume their work when the light has disappeared. (See E. F. M., par. 39, Part V for placing relief on work when tasks are individual, not group tasks.)

80. *Shaping bottom of trenches.*—The digger left to his own devices will make the bottom of the communicating trench concave; the mud will then settle to the center which the men's feet will soften and gradually wear down. When the trench is cleaned the mud will be taken out in a series of holes along the center, making walking very difficult. This is a detail that should be insisted on when work is going at a high rate in the first line and a shift of workers is on every night. It has been reported that more men are injured by sprains than by hand grenades and bombs, and a sprain lays a man up for a month. The bottom of the trench should therefore be made convex or rounded upward just like the cross section of a good road. No other form should be allowed.

81. *Stairs or steps* from the bottom of communicating trenches to the ground level, are important at all crossings where possible, and bridges over lateral trenches will furnish practically a roadway

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The elementary training need take only two or three weeks, but what is learned should be learned with great thoroughness, so that each man in actual operations will know exactly what he has to do and what to expect of his neighbors. This instruction can be given from the Engineer Field Manual, Part V, and should include the use of the different tools listed in the Unit Equipment Manual, the most effective way of handling them, systematic distribution of tools and tasks, cooperation so that men will not get in each others way, and knowledge of the adopted sections and types of construction.

The types of construction are few in number, and the men should be trained to build without hesitation the normal or usual type of firing trench, communicating trench, machine-gun emplacement, covered shelter (Pl. III), and to break out and work a sap as described in the Engineer Field Manual. Special constructions beyond the above list can be given later to those best qualified to receive it or in cases of special emergency.

Instruction of troops should prepare them to take their places immediately among the combatants when they go to the front as reinforcements. For their own sake they must know all the latest methods of combat, both defense and attack.

It has been noted that in training the reserves and troops in depots in some of the European armies not enough attention is given to grenade instruction, sapping, rules for life in cantonments, duties in the trenches, actual assaults, and combats in a labyrinth of communicating trenches and barricades.

All depots should have on hand a sufficient number of tools, sandbags, and unloaded but primed grenades, without which training for trench work is purposeless and futile. Combats with blank cartridges should be carried out daily in lines of entrenchments copied after those of some known and tested field of battle. The men in reserve need instruction for the work they will take up at the front and should have full course in work, discipline, and life in the trenches.

EQUIPMENT AND MAINTENANCE OF FIELD FORTIFICATIONS.

84. *Observation.*—The observation of the enemy is of first importance in position warfare. It should give complete knowledge of all the elements of the hostile line and prompt information of any movement of the enemy. It is effected by observation from the ground and observation by aircraft.

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Observation from the ground is divided into three echelons:

(1) Observation in front of the firing line from small posts and listening posts.

(2) Observation on the firing line by sentinels and lookouts.

(3) Observation in rear of the firing line by artillery observers, sentinels, and lookouts of the shelters.

It is effected by the infantry and artillery.

Observation in front of the firing line is effected by small posts or listening posts of from one to eight men placed in rifleman's pits, shot holes, organized shell craters, or in short semicircular elements of trench connected with the firing line by sap or low mine gallery. Their protection is assured by their invisibility. The retreat of the observers is protected by a system of branch galleries whose entrance into the main gallery can be closed rapidly, or by a barbed-wire protection placed over the sap. The lookouts in small posts are placed in very short trenches, which are provided with loopholes. Protection at short range against grenades is secured by a network of wire.

Observation on the firing line is effected by lookout posts organized preferably at the salients where the view is more extended. (Pls. I and III.) These posts give a view over the enemy's firing line; they are provided with periscopes, range finders, and large scale maps. They should be concealed by all possible means; observation is carried out under good conditions only when it is done without the knowledge of the enemy. The posts should preferably be constructed on the right of a traverse and in an excavation in front of the trench wall.

The observation posts, even of the infantry, are not necessarily in the firing line or in the listening posts. Often in rear, points will be found which will give an excellent view and will not attract the enemy's attention. The term "observatory" is often employed for this kind of observation post. The observatories generally have a more extended view than the lookout post; they are protected and have means of communication such as telephone, heliograph, messenger, carrier pigeons, wireless. They may belong to the infantry, the artillery, or higher commands. The observatory may be occupied by the commander himself or by an observer who represents him. In any case the observatory is near the command post. (Pl. III.) It must have a low parapet, be defiladed from view, and proof against large projectiles.

The location of the lookout posts and observatories must be determined in accordance with a complete plan for each supporting point

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or sector of defense. No part of the hostile front should be free from observation and the parts of the front favorable for the attack of the enemy should be specially watched. An observatory should be located near the command posts of the commanders of strong points, supporting points, and sectors. Those of the last two must have extended views over the whole of the terrain.

85. *Illumination of the battlefield.*—In position warfare it is necessary:

(*a*) To discover and keep in touch with the movement of the enemy during the night.

(*b*) To seek out and illuminate hostile objectives so as to fire upon them.

(*c*) To blind the enemy.

These results are obtained with searchlights. The smaller ones, about 12 inches, are only acetylene or incandescent electric, and have a short range of 300 to 1,000 yards. The larger, 24 to 36 inches, are of the electric arc type and have a range of 2,000 to 5,000 yards. They can also be used for signaling. They are placed in shelters similar to those for machine guns, located so as to flank the line of fire. (Pl. III.)

86. *Lines of information.*—During a bombardment, the maintenance of lines of information becomes very difficult, but it must be accomplished by all possible methods, such as:

(*a*) Installing telephones under strong shelters.

(*b*) Using lead-covered cable, buried 6 feet deep, especially for the lines connecting the regimental, brigade, division, and corps headquarters.

(*c*) Placing rockets in all shelters and observatories where officers or noncommissioned officers are posted.

(*d*) Preparing posts for visual signaling, safe from bombardment and defiladed from view of the enemy. These posts are constructed in shelters similar to those for searchlights and are provided with horizontal loopholes with openings to the flank or rear.

The problem of the telephone is one of the most important and has yet to be satisfactorily worked out. The allowance of apparatus must be greatly increased and systematic organization of men and matériel is urgently demanded. All persons along the line, passers-by, guards, and the like, must have an interest in maintaining the lines and keeping clear of the wire. Every noncommissioned officer should have a few staples or long hooks in his pocket so as to place a fallen wire temporarily out of reach of passing troops. Artillery wires should be placed on one side of the trench and infantry wires

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on the other; they must be high enough to clear men passing at night, loaded and weary, and at trench crossings they must be carefully protected. Constant supervision and repair of the lines is necessary. Lines with too many phones in series should be avoided. Multiply the centrals and reduce the phones on the same line to three or four.

87. *Depots for material and ammunition.*—These consist of galleries of variable dimensions, opened in the walls of the trenches and approaches, and usually lined with timber like mine casings. The entrance should be closed with a strong door. They are used to store water, rations, ammunition, grenades, pioneer tools, portable searchlights, field glasses, maps, range finders, periscopes, lighting pistols, and rockets. Depots for engineer material are usually installed in the angles of the approaches. Depots for water, rations, tools, and sandbags are usually established about 20 yards to the right of the company command post (par. 90). Depots for arms, ammunition, bombs, grenades, and rockets are about 20 yards to the left of the same post. An inventory of the material should be kept up to date at the company command post. (Pl. III.)

88. *Machine guns.*—The general principles of their employment are:

(1) The personnel and matériel should be protected from fire as much as possible.

(2) In order that they may be available at the moment of attack, it is indispensable that they survive the bombardment. Their protection must therefore be specially provided for by employing all of the following means:

(*a*) Placing them under shelter.

(*b*) Making their emplacements invisible.

(*c*) Dispersing them laterally and arranging them in echelon.

(3) Casemates must be used only when they can not be seen by the enemy, such as on the reverse slope or in woods or villages. (Pl. III.)

(4) The great importance of making them invisible necessitates the construction of firing emplacements outside the shelters, but close enough so that the guns can be put in action with the least possible delay.

(5) The firing emplacement may be protected by a light roof with very slight height (Pl. III), or it may be entirely without overhead protection. The emplacement may consist simply of a pit in the open field, situated in front or in rear of the parapet, and connected with the shelter by an underground passage. The

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machine gun should be placed in action at the last moment. It may be simply placed on the edge of the pit without any protection, but preferably should be covered by a light shield, or a low parapet joining the natural slope of the ground with a gentle slope. The pit should be carefully hidden and will not usually be discovered by the enemy. Emplacements of this nature are frequently employed in rear of the firing line.

(6) When the firing trench is situated on the reverse slope, machine guns should be emplaced in concealed pits in front of the trench, and connected with it by underground passage.

(7) The requirement of invisibility makes it necessary to conceal all the approaches to the firing emplacements by making them underground, and to increase the number of emplacements so that it will not be necessary to fire daily from those to be used in case of an attack.

(8) The emplacement of too many machine guns in the first line is dangerous; in order to stop an attack they should be echeloned to the rear. In favorable terrain, flank fire should be provided, to mow down the attacking lines as they push forward. Therefore, the available machine guns should be distributed between the firing trench and the terrain in rear, with each emplacement prepared in a manner suitable to the terrain and object in view.

89. *Emplacements and shelters for trench weapons.*—In trench warfare, batteries of light mortars and other trench weapons are generally situated between the cover and support trenches. (Pl. III). Like machine-gun emplacements they are of two types, viz, with and without overhead cover. Whenever overhead cover is used, if practicable alternate emplacements should be constructed near by. The emplacements should be concealed as much as possible, and for this reason the command should not be greater than that of the adjacent trench. The guns should be dispersed laterally and in depth as indicated for machine guns.

90. *Command posts.*—For every 100 to 150 yards of new trench constructed there should be a command post for the company (Pl. III), or battalion commander, the brain center of the new organization of trench world thus created. These command posts may be the vital points of some future battlefield. They should be placed conveniently near some main communicating trench and should be numerous enough for all uses during an action. Each command post must have a specific identifying letter or number, the series not to be repeated where there would be danger of confusion, so that when an officer comes to take possession he can immediately record

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his address without the least danger of mistake. These posts will be marked by big signboards and on the map or plan by a clearly legible conventional sign.

Command posts if located and marked as described will thus form definite spots in the terrain, known to every one and used as the origin of coordinates for indicating other near-by points. For this reason the necessary supplies that troops in the vicinity may need in an emergency should be collected at some point definitely located with reference to a command post. The command post of every captain should therefore have at 20 yards to the right a depot for water, food, and sand bags; at 20 yards to the left a water-tight shelter for cartridges, grenades, and rockets. When these are needed urgently by troops in front they can be found and furnished. This coordination of the supply depots with the command posts of the captains must be regulated and insisted upon by the higher commanders.

The command posts being thus important centers and not the mere shelter for the company commander, they must be uniformly and positively supplied with certain articles as follows: A table, a water barrel, a lamp, oil and candles, a periscope, simple box or pigeonholes, a gas mask, an oiled cloth, and a curtain. All this material must be placed in the post when it is built and not distributed the day before an attack to the company commanders. In each command post there is a pad or book of printed forms for orders, requisition for supplies, and other necessary papers.

The command posts may also be used advantageously as material depots where the supplies for the troops will be continually collected and inventoried.

91. *First-aid stations.*—These are connected with the cover or firing trench by a communicating or approach trench wide enough to carry a litter. They are constructed like other shelters. The walls are covered with straw or hurdle work, which must be frequently changed. They should be at least 8 by 12 feet in size. Two cots should be placed against one wall and a bench for the wounded to sit on against the other. (Pl. III.)

92. *Kitchens.*—These should be constructed in shelters. (Pl. III.) The stovepipes should project somewhat above the top of the shelter to secure good draft. In addition, numerous ventilating holes must be made. The shelters should be large enough to accommodate the rolling kitchens. Small fires built of dry wood in the bottom of deep trenches do not betray the position of the trenches.

93. *Lavatories.*—These are improvised of tin or wood so as to form a number of basins in a row, with holes in the bottom, placed

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above a wooden trough which receives and carries off the water to a drainage pit. There should be a grating for the men to stand on. They should be constructed in a branch trench, covered if practicable. The floor of the trench should have a decided slope for drainage.

94. *Shower baths.*—These should be installed in a deep shelter or in a cave shelter. A simple arrangement is to provide one or two kettles for heating water, tubs or casks for storing water, placed about 9 feet above the ceiling of the shelter. The tubs or casks should be connected with a pipe fitted with sprinklers, properly spaced. There should be a grating on the floor, and the bottom of the approach should have a fairly steep slope toward a drainage pit.

95. *Water supply.*—This usually consists of several large casks, filled by pipes, if practicable; otherwise the water is carried to them. There should be an interval of at least 10 yards between casks to avoid crowding and mud puddles. (Pl. III.)

96. *Sign posting the approach and communicating trenches.*—At all crossings two solid signboards must be set into the berm, beyond the reach of involuntary blows of passers-by. Their position is important. Whoever sets them must put himself in the position of both the passer-by coming from the front and the one coming from the rear and then arrange the signboards so that no one can mistake them.

Often the big approach trenches are named and marked only up to a parallel, beyond which they are doubled or quadrupled by others which absorb them into their special system of notation. This is a mistake. The approach trench must keep its name up to the parallel of departure, because it forms an important known feature or avenue in the trench system and the terrain.

97. Besides the sign posting, a simple rule prevents confusion between an approach trench and all those connected with it; that is, wherever there is a crossing or a fork, to keep the bottom of the principal approach trench at 12 to 16 inches below that of the offshoot trench. It is thus clear that if one takes a step up he is leaving the principal approach trench. In the same way at a right-angle turn a few blows of a pick will form a small arc of a circle and suggest the continuity of the main trench. These small efforts will save many an error and much confusion.

98. It is desirable to have traffic in one direction only in an approach trench, so one set is built for bringing troops up from the rear and another generally parallel for evacuation or moving to the rear. Movement in the contrary direction should be allowed only by special order.

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When parts of trenches are captured, steps must be taken immediately to clear them of insects which swarm in them and transmit disease germs, particularly typhus. Straw should be burned in the trenches and shelters, and all wood should be whitewashed.

103. *Protection against asphyxiating gas.*—All occupants of the trenches must be provided with gas masks. In the shelters thorough ventilation must be provided by boring vertical or inclined holes with an earth auger through the roof. (Pl. III.) These can also be used for periscopes. Against asphyxiating gas it is necessary to seal hermetically the shelter as soon as the alarm is given. For this purpose two curtains of canvas or blankets are placed at the entrance, a short distance apart. There must always be a barrel of a solution of hyposulphite of soda in the shelter, which should be sprayed into the air.

104. *Protection against bombs and grenades* is secured by a grill of wire netting placed in front of the trench. The top of the grill should be so placed that a bomb passing over it will clear the trench.

105. *Trip and alarm wires* should be provided at important points. These may be arranged to light a flare or give some other signal to disclose the advance of the enemy. Lookouts should be provided with some means of giving a special alarm at the approach of asphyxiating gas.

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be able to get out to bomb the front trench if captured by the enemy, or for the garrison to get out to counter attack across the open.

The surprise position behind the parados and the exit must be most carefully hidden from view.

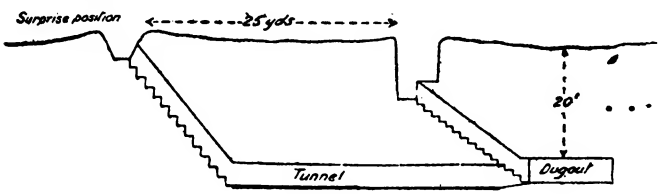

FIG. 2.

6. *Notes on construction.*—In the construction of dugouts the following points are to be observed:

(*a*) *Entrances.*—They should be well concealed and have not less than 5 feet of headcover with a bursting course. The best protection is usually obtained by well strutting the trench opposite the entrance.

Antigas blankets must be fitted to all entrances.

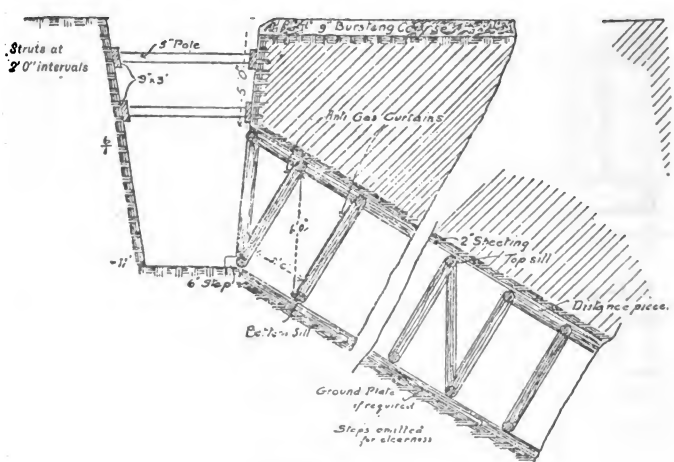

FIG. 3.

(*b*) *Galleries.*—Galleries leading to dugouts should have an incline of 45° except in the case of dressing stations, when it should be 30°.

Internal dimensions of galleries to be 2 feet 6 inches wide and 6 feet high. This involves using frames 2 feet 6 inches by 4 feet 6 inches.

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Frames of standard dimensions will be supplied from corps or division parks; they are not to be made on the site.

Frames will be made of not less than 6-inch roughly squared timber; they will consist of a top sill and bottom sill and two posts, properly shouldered and fitted.

Frames must be put in at right angles to the slope of the gallery and be strengthened by distance pieces at the top or single diagonal struts from top to bottom; these should be secured by nailing.

In treacherous soil these frames should rest on ground plates.

Wooden steps to be provided, 1 foot tread 1 foot rise.

Frames should be spaced not more than 2 feet 6 inches in the clear. (See fig. 3.)

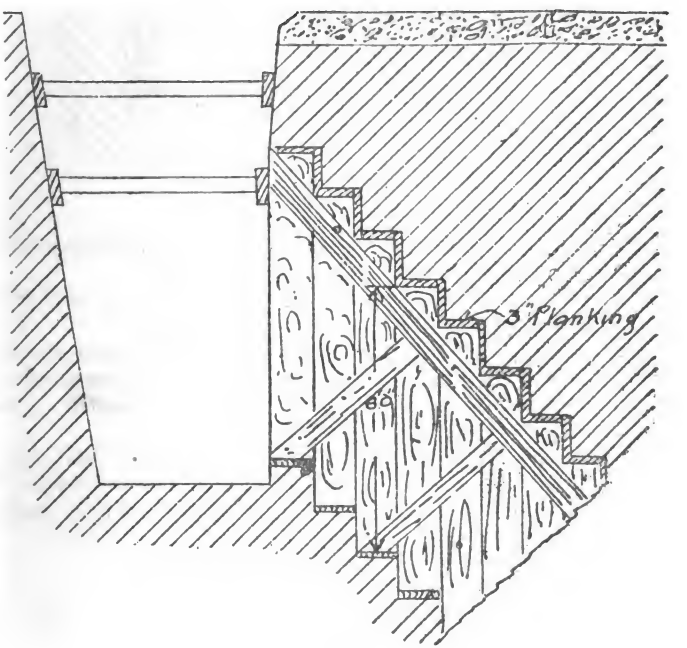

FIG. 4.

When material is available, galleries may also be made of mine cases. These must be made of 3-inch planks, and be prepared and fitted in the parks.

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REVETMENTS.

1. *Local conditions.*—Different natures of soil require different revetments.

The following notes apply to revetments suitable to the soil on the present front of this corps. In Flanders, where the clay is soluble, modifications would be necessary.

2. *Slopes requiring revetment.*—Front parapets and sides of communication trenches usually require revetment. The back wall of fire trenches should not be revetted unless they will not otherwise stand, or unless they have been blown down by shell fire and require rebuilding.

3. *Revetments.*—If the fire step is not a wooden one, as is preferable, the best revetments in order of suitability are planking, hurdles, corrugated iron, expanded metal, or three thicknesses of rabbit-wire netting nailed on frames.

Above the fire step, brushwood is the best revetment, as the stakes, being loose, do not impede repair work in the event of the trench being blown in.

4. *Notes on revetments.*—The following are a few points with regard to various kinds of revetments:

(*i*) *Brushwood.*—To make a brushwood revetment, stakes should be driven into the ground from 1 to 2 feet apart along the line of parapet, the brushwood laid behind, and the whole anchored to the parapet.

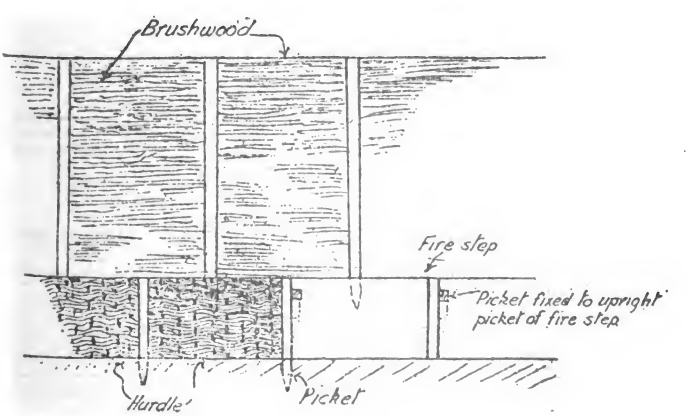

FIG. 8.

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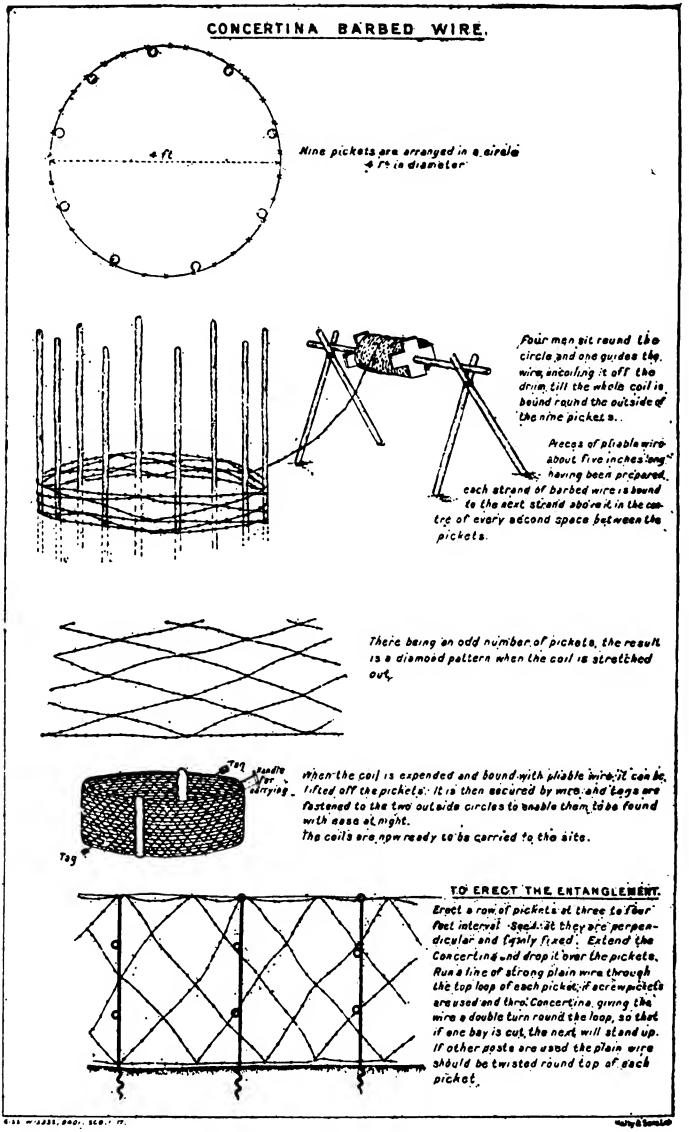

FIG. 9.

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to the parapet. The method of doing this is practically the same in all cases. The difficulty is to place the anchors in position if the parapet has been laid, and it often means that the parapet has to be pulled down to enable the anchor to be put out. This may, however, sometimes be avoided by the use of an iron needle. This can be pushed through the parapet, the wire put through the loop and pulled back into the trench. These iron needles can be made in any workshop.

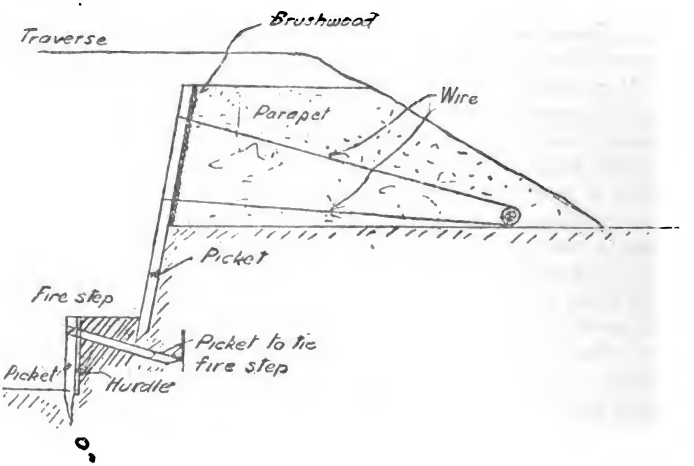

FIG. 11.

A common fault is to use only a single thin wire. If stout wire is difficult to obtain, three strands of thin wire should be used instead.

In the case of a completed parapet a picket is often the best form of anchorage.

TRENCHES.

A broad, deep, well traversed trench, with unrevetted sides, is the best, as it is less likely to get blocked, and the danger of men being buried is reduced. The dimensions recommended are: Fire trench—breadth at bottom, 2 feet; breadth of fire step, 1 foot 6 inches; amount of cover, 7 feet; slope of sides of trench, 4 to 1. Communication trench—breadth at bottom, 3 feet; amount of cover, 7 feet; slope of sides of trench, 4 to 1. *A berm at least 1 foot wide must always be left on both parapet and parados.* Time should not be wasted in rebuilding and revetting narrow trenches so as to keep them narrow. They should be reconstructed as broad trenches

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Appendix I.

CONSOLIDATION OF TRENCHES AND LOCALITIES AFTER ASSAULT AND CAPTURE.

1. CONSOLIDATION OF A CAPTURED SYSTEM OF TRENCHES.

The capture of a system of hostile trenches is an easy matter compared with the difficulty of retaining it. A thorough knowledge of the principles, a careful study and correct use of the natural features of the ground, and a detailed preparation and organization of the work, are necessary; but success will only result if there is also an absolute determination on the part of all ranks to get the work done promptly at all costs.

The principles of the consolidation of captured trenches are, briefly, as follows:

(*a*) To establish a series of strong points or supporting points, wired all around and mutually supporting each other according to the ground. These points should be provided with machine or Lewis guns at once.

(*b*) To provide good communication to the rear from these points.

(*c*) To fill in all hostile trenches within bombing distance of the points occupied.

(*d*) To establish, if possible, simultaneously with the consolidation of strong points in the front line, a number of supporting points in rear. These points should, if the ground is favorable, be placed to cover the intervals between the works in the front line.

(*e*) The strong points can later be connected to form a continuous front line.

The above principles must be applied with due regard to the natural tactical features of the ground. The satisfactory siting and consolidation of a position will largely depend on the power possessed by the officers on the spot to recognize during the various stages of a battle the minor features of real tactical importance. This ability is only acquired by previous training, and is a quality which every officer must study to possess. The size and trace of the "strong points," as well as the intervals between them, will vary

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(*a*) Barricade and picket all exits. Establish strong points near exits to cover approaches or any streams or tracks which might serve to guide a counter attack. Commence work on keep, preferably at village crossroads. Barricade roads.

(*b*) Reconnoiter for cellars.

(*c*) Establish communications, giving cover from view, radiating from keep to outer strong points, and from keep to the rear.

(*d*) Construct bombproofs in cellars at strong points and keep, false roofs to cellars, etc.

(*e*) Complete keep.

(*f*) Improve communications at (*c*) above, to give cover from fire.

(*g*) Make lateral lines of communication between strong points.

Strong points should be established (if it is possible to do so) to the flank of conspicuous buildings likely to afford good targets for hostile artillery fire. In the case of keeps in villages, this is often impossible owing to the presence of church spires. It is, however, preferable to have a keep, even with this disadvantage, that is central, accessible, and strong against infantry assault. It should be remembered in this connection that by the time hostile infantry can assault a village keep hostile artillery fire will necessarily have ceased.

Woods.—As in the case of villages, plans should be prepared of the locality.

There has been much discussion in the past as to what part of a wood should be occupied. Experience has proved that, owing to the great advantages afforded by cover from view, the position to take up in a wood is just so far within the outer edge as will permit of good view into the open. In this connection it should be remembered that in course of time shell and rifle fire thins out the edges of woods considerably. It is therefore advantageous in the first instance to take up positions slightly in rear of those which may appear at the moment to be most advantageous.

If, as is often the case, the wood is surrounded by a hedge, there is a natural tendency to make trenches against this hedge. This is to be avoided. A hedge forms a very good obstacle against assault, with the addition of a little wire. If it screens the view it can be quickly thinned.

The order or urgency of work is as follows:

(*a*) Establish strong points for all-round defense at the corners and salients of the wood. These are the points which are most liable to counter attack.

Establish central reserve, reconnoiter, blaze, and clear communications.

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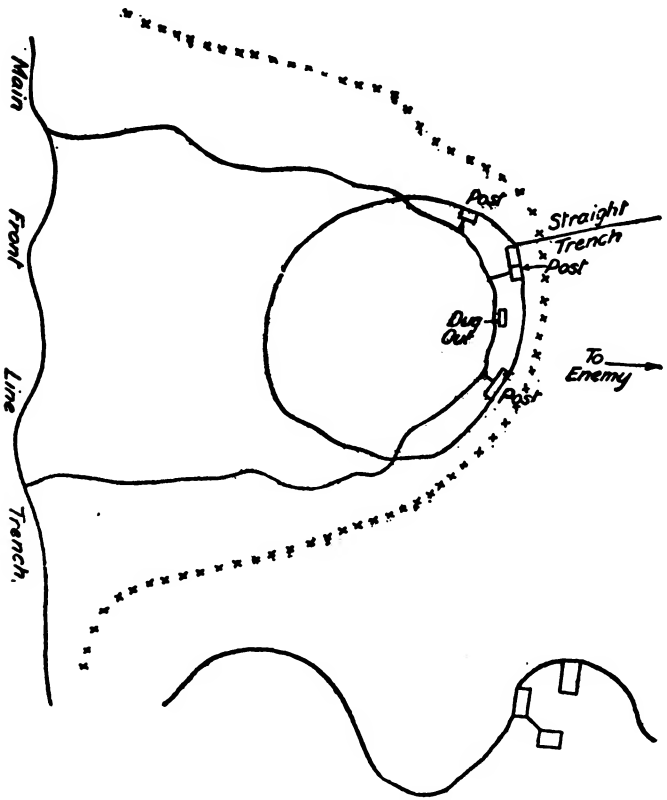
VII. There are two main methods of holding craters:

(*a*) *Method A.*—(See sketch below and pl. A).

This method should usually be employed after the explosion by us of a mine in the enemy's trenches or in the area where it is known that the enemy is not engaged in mining.



The front "lip" of the crater is held by means of several posts. Two communication trenches lead into the crater, one on each side, and give lateral communication between the posts. One or two dugouts are constructed in the sides of the crater.

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(*b*) *Method B.*—(See sketch below and pl. B.)

This method should usually be employed when the enemy has exploded a mine in or near our trenches, or when we have exploded a defensive mine close to our own trenches.

The rear "lip" of the crater is held. Wire is thrown inside the crater. One or two loopholes are cut through the rear "lip" so as to command the inside of the crater.

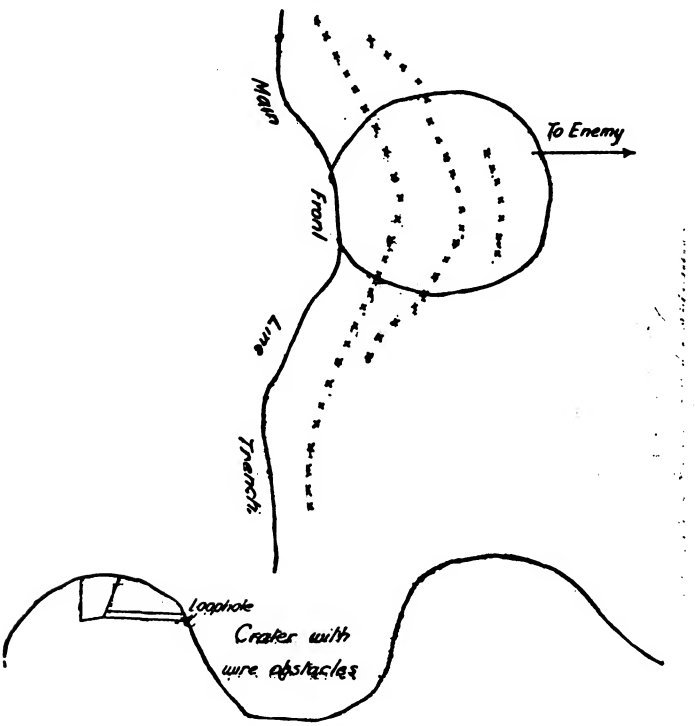

Plate C shows a scheme for converting the area behind the lips of a series of craters, which have been occupied, into a strong post.

The importance of rendering the means of access to the lip secure from bombing attack is not always recognized.

VIII. Work should be carried out in the following order:

(*a*) Construction of one or two posts in the "lip" of the crater.

(*b*) Wiring the front of posts and filling in or straightening trenches leading from it toward the enemy.

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(*c*) Digging of communication trenches up to the crater.

And, if far lip has been occupied:

(*d*) Digging trench for lateral communication inside the crater.

(*e*) Completion of wiring front of crater and construction of further posts in far "lip."

(*f*) Construction of dugouts.

(*g*) Improvements to the above.

It should usually be possible to do (*a*), (*b*), and (*c*) together.

4. NOTES ON RAPID WIRE ENTANGLEMENTS.

One of the first requirements in consolidating a position is to get some wire out in front of it.

The following general principles regarding the construction of wire entanglements should be observed:

(*i*) The rear edge of the entanglement should be about 20 yards from the trench; if the trace of the entanglement is irregular and does not follow the trace of the trench, it will make the task of the hostile artillery more difficult.

(*ii*) The depth of the entanglement should be as great as possible, and at least 30 feet. The wire available should be expended in forming a deep entanglement rather than a "heavy" one (i. e., one with a large amount of wire between each set of posts). The construction of two belts with an interval between them, rather than one belt of twice the depth, gives the hostile artillery a deeper target to destroy, without increasing the material required for constructing the entanglement, except by one row of pickets.

(*iii*) There will seldom be time in rapid wiring to "dig in" the wire for concealment. Every advantage should be taken, however, of natural folds in the ground, long grass, or brushwood, or other means of concealment.

(*iv*) Wire entanglements should be 2 feet 6 inches to 3 feet high.

(*v*) The posts in a row should be about 6 feet from each other, and the rows about 6 feet apart. If wooden posts are used they must be strong; light posts are useless.

(*vi*) The difficulties of crossing an entanglement are increased if it is not too regular, e. g., if the heights of the posts above ground and the distances between them are varied. For rapid wiring drill, however, a regular entanglement is easier to construct.

To insure that an obstacle can be erected with rapidity and in silence, every one of the working party must know what he has to do and work so that he does not get in the way of the others.

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This necessitates some form of *drill*. There are a large number in use, of which a selection is given below. The following notes and rules will be found useful in carrying out any form of drill for constructing wire entanglements:

(*i*) The party should, as far as possible, work so that the obstacle is always between them and the enemy. Each wiring party should have a double sentry lying down about 30 or 40 yards toward the enemy to prevent patrols sniping or bombing the party. If circumstances necessitate it, a special covering party should be provided.

(*ii*) The party should work extended and not bunched together.

(*iii*) Large parties, in which each group of men has only one operation or duty to perform, will erect entanglements quicker than a small party, in which each man has several duties to perform in succession, unless latter is very well drilled.

(*iv*) The best *unit* of entanglement is about 40 or 50 yards long. Its construction can then be controlled from one point. This distance is also a convenient interval to leave small gaps for patrols.

(*v*) A line of posts is best laid out at night by putting down a tape or string with the intervals of the posts marked by bits of rag or sandbag tied on to it.

(*vi*) The end of a coil of barbed wire will be found secured on the drum tucked under the standing part. In the dark it is very hard to find and release. Coils should, therefore, be prepared by daylight. A good method is to attach a piece of string to the end, uncoil the roll half a turn, re-coil it on a piece of old sandbag, and fasten it up by the string. The end of the wire can then be readily found in the dark. The pieces of tin on the wooden drums should be removed to prevent noise. It may be found convenient, to make carrying easier, to re-coil the barbed wire in smaller coils on a stout stake.

(*vii*) Pickets should be made up into bundles of one-man loads. They should be firmly tied with plain wire or brought up in sandbags. The latter is the surer way of keeping them together; at any rate, with small wooden pickets. A drum of barbed wire is best carried over the shoulder, with a stout stake passed through it, which also serves for uncoiling the wire. Pickets and wire should be dumped by the carrying party outside the trench behind the center of the length to be wired.

(*viii*) Mauls, if used, should be muffled by nailing on a leather face or with sandbags. About eight thicknesses of sandbag material are necessary to be of any use.

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(*d*) Care must be taken that all the posts are originally screwed in so that the eyes point the same way, otherwise delays will occur in the wiring.

(*e*) Loose bundles of iron screw posts and pickets cannot be carried noiselessly. It is advisable, therefore, to wrap them round with a sandbag, secured by a light turn of wire with the ends twisted together. Enough end to this wire should be left so that it can be untwisted by hand without pliers.

(*f*) Short stakes or bats must be provided to fit the top eye of the posts in order to screw them in. The helves of the entrenching implement serve the purpose.

EXAMPLES OF WIRE DRILLS.

Picket is used to mean a short picket used as a holdfast.

Post is used to mean a longer upright.

Fence is used to mean a series of wires on a row of posts.

The conventional signs used in the diagrams are explained in figure 2.

In all the drills given, unless otherwise stated, it is assumed that:

(*a*) The length to be erected is 50 yards.

(*b*) The stores required are collected at a point behind the center of the length in a convenient order.

(*c*) The line of the fence has been marked or indicated.

(*d*) The drums of wire are opened and the ends ready.

(*e*) Bars or sticks are run through the drums, so that the wire can be uncoiled readily.

(*f*) Short sticks for screwing in the pickets are carried by the men requiring them (or mauls if wooden or angle iron pickets are used).

(*g*) All wirers have hedging gloves and wire cutters; and have their legs protected by gaiters or sandbags.

(*h*) Each number consists of two men who work together, and the numbers commence work in succession at a suitable interval (say 4 posts apart). Thus Nos. 2 move off as soon as Nos. 1 have the desired start, Nos. 3 at the same interval behind Nos. 2.

(*i*) All work is commenced on the left.

(*j*) The men who put the top wire on a fence stay the end post to short pickets.

(*k*) On completion of each operation or "duty" detailed in the drill, all men should return to a fixed place, in order to prevent confusion, if some work faster than others.

(*l*) Spare men are at hand to replace any casualties.

The drills are primarily intended for use with iron screw posts, but can be used for wooden or angle iron posts with slight modifica-

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tions. If the soil permits of posts being screwed in to the bottom eye, no stays are necessary, and three horizontal wires in the fence, instead of four, will be sufficient.

No estimates of stores required are given, as the distance apart of the posts and the amount of wire used must depend on what is available.

Drill No. 1.—Double Apron Entanglement.

(See fig. 3.)

Working party, 12 men exclusive of noncommissioned officers.

First duty:

Nos. 1. Lay posts in position on ground A.
Nos. 2. Front rank—assists Nos. 1.
Rear rank—holds up posts for Nos. 3 to screw in.
Nos. 3. Screw in posts, separately.
Nos. 4. Lay front and rear pickets in position.
Nos. 5. Screw in front pickets B.
Nos. 6. Screw in rear pickets C.

Second duty:

Nos. 1. Bottom wire of fence A.
Nos. 2. Second wire of fence A.
Nos. 3. Third wire of fence A.
Nos. 4. Top wire of fence A.
Nos. 5. Front diagonal between A and B.
Nos. 6. Rear diagonal between A and C.

Third duty:

Nos. 1. Top horizontal wire on front diagonals A B.
Nos. 2. Second horizontal wire on front diagonals A B.
Nos. 3. Bottom horizontal wire on front diagonals A B.
Nos. 4. Top horizontal wire on back diagonal A C.
Nos. 5. Second horizontal wire on back diagonal A C.
Nos. 6. Bottom horizontal wire on back diagonal A C.

This drill involves Nos. 5 in "second duty," and Nos. 1, 2, and 3 in "third duty," working in front of the fence.

In the "first duty" No. 2 rear rank holds up a post for No. 3 front rank to screw in until it gets a bite in the ground. He then holds up a post for No. 3 rear rank, etc.

This obstacle and others of the same nature can be deepened by adding similar bays behind it. The posts in successive bays should cover the intervals between those in front of them. (See fig. 4.)

If two bays are made, the obstacle can be increased by tossing loose wire into the valley between the posts.

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time, it would be sufficient, if time presses, to stay the pickets merely by connecting the heads. (See fig. 9.) "Gooseberries," etc., can be thrown into the space between B and C.

Another variation is to put loose wire or French wire between fences B and C and crisscross plain wire to connect the tops of the pickets. (See fig. 10.)

A further variation can be introduced by placing the posts so as to form squares instead of triangles. (See fig. 11.)

Drill No. 6.—Double Fence.

(See fig. 12.)

Working party, 28 men exclusive of noncommissioned officers.

This entanglement is designed for stout wooden posts well driven in, or screw posts screwed in down to the bottom eye; no holdfast pickets are then required.

The drill only requires one duty from each pair of men.

The apron is of a different pattern to those previously given; the wires miss alternate pickets.

Three horizontal wires can be used for the fence instead of the "gate" pattern shown.

ORDER OF WORK.

(1) Under superintendence of two noncommissioned officers all hands carry up and place the posts on the ground.

(2) Nos. 1. Drive or screw in posts in front fence A.
Nos. 2. Drive or screw in posts in back fence B.
Nos. 3. Bottom wire 3 of fence A.
Nos. 4. Diagonal wire 4 of fence A.
Nos. 5. Diagonal wire 5 of fence A.
Nos. 6. Top wire 6 of fence A.
Nos. 7. Bottom wire 3 of fence B.
Nos. 8. Diagonal wire 4 of fence B.
Nos. 9. Diagonal wire 5 of fence B.
Nos. 10. Top wire 6 of fence B.
Nos. 11. Apron wire 11.
Nos. 12. Apron wire 12.
Nos. 13. Apron wire 13.
Nos. 14. Festooned wire 14.

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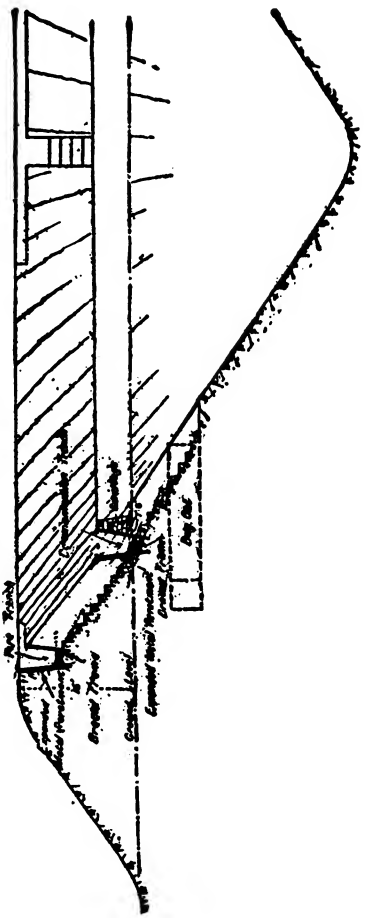
ELEVATION PLATE A.

Approx. Scale 1″ = 12′.

Enemy Front.



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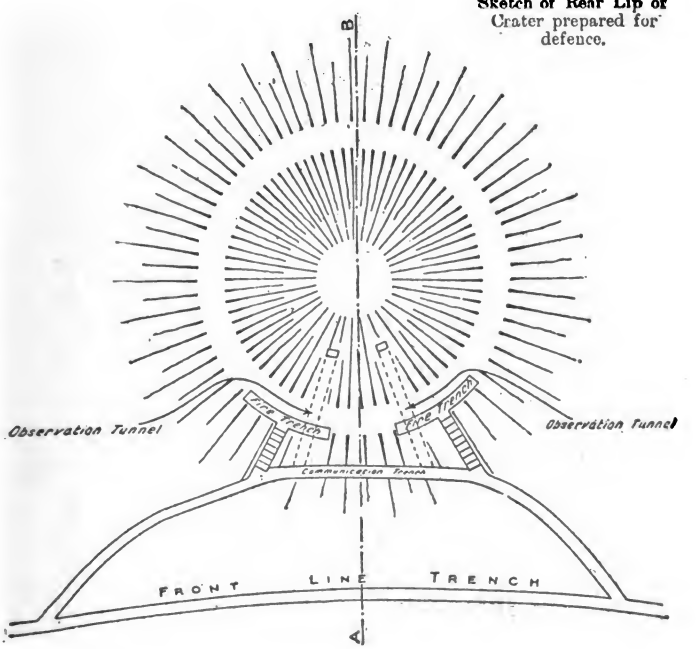
PLAN

Plate B.
Sketch of Rear Lip of Crater prepared for defence.



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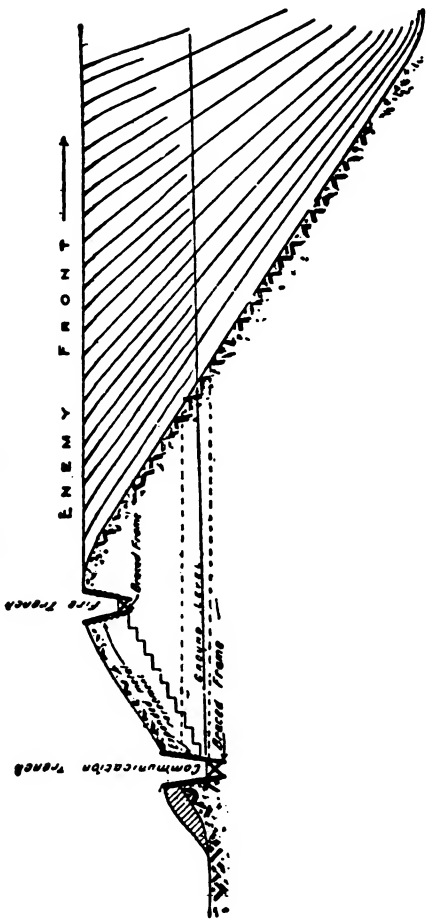

SECTIONAL ELEVATION ON A. B.

Approx. Scale 1″=24′.

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Plate C.

Sketch Plan.

Shewing proposed system of defence by bombing trenches behind craters where no field of fire can be obtained.

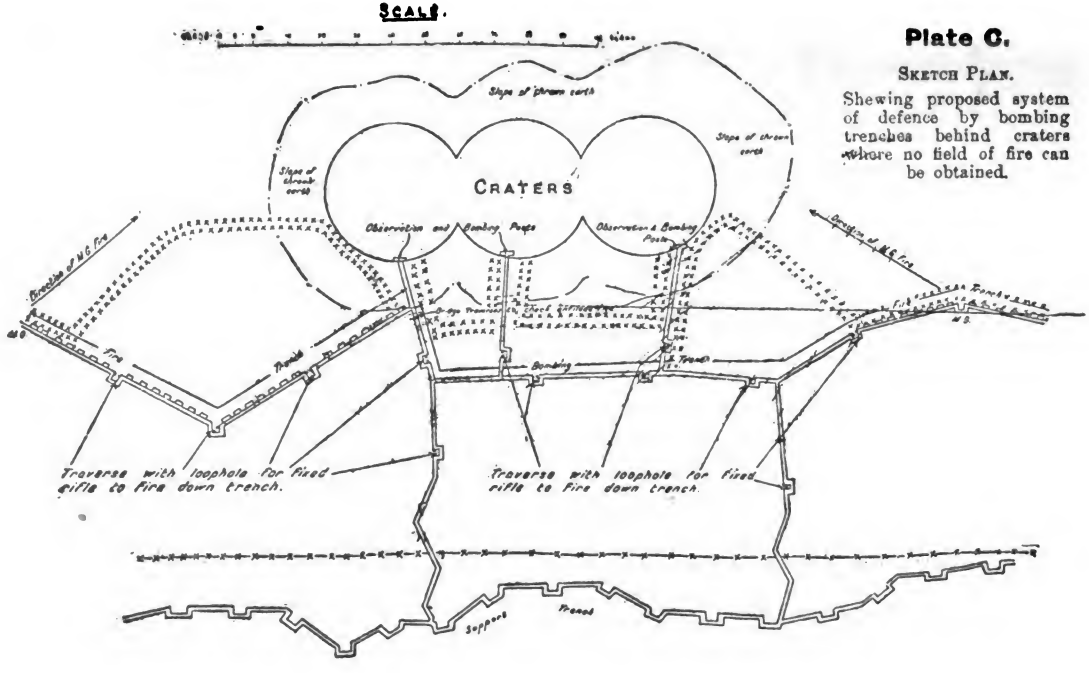

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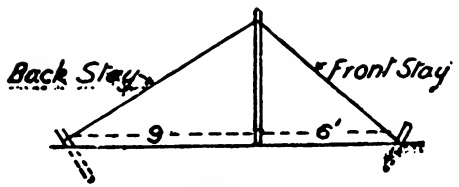
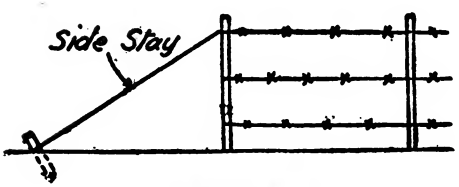
Fig. 1.



SECTION.



ELEVATION.

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Fig. 2.

CONVENTIONAL SIGNS USED IN PLATES.

PLAN. ELEVATION.

Posts (long).

Pickets (short).

In fence.

1 Horizontal Wire.

2 Horizontal Wires.

4 Horizontal Wires.

Top end.

Inclined Wire.

Low end.

Gate.

Gate and 2 Horizontal Wires.

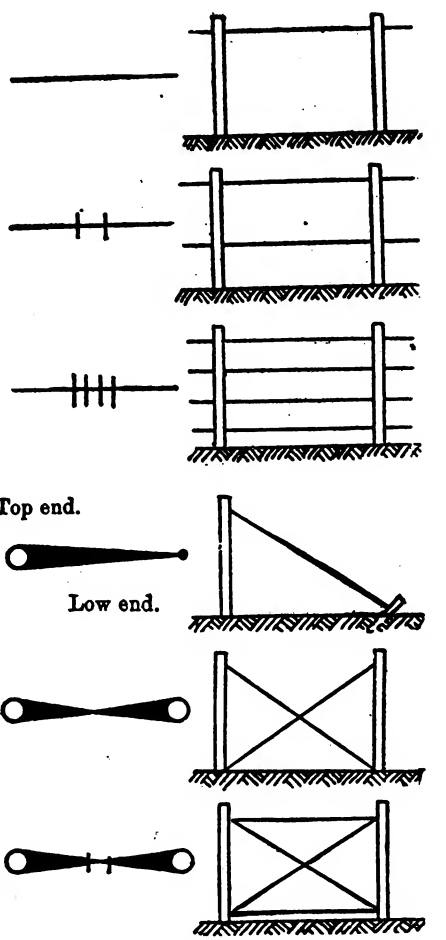

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Fig. 11.

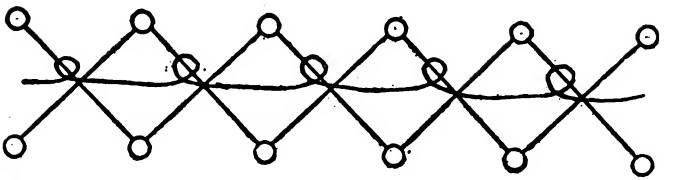
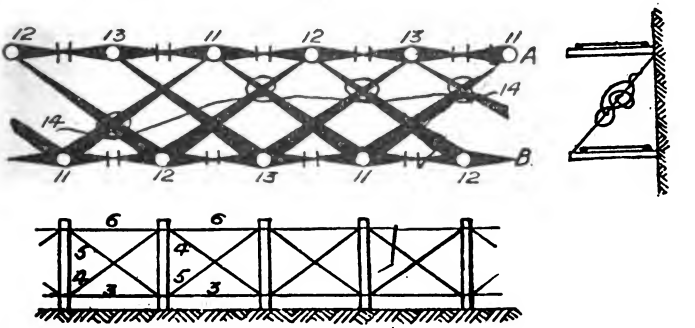
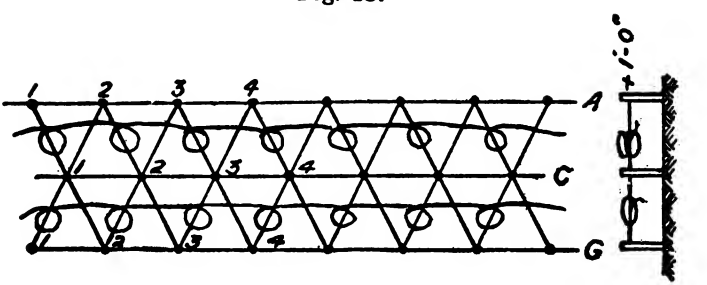


Fig 12.



Elevation of A and B.

Fig. 13.



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Appendix II.

NOTES ON WIRE ENTANGLEMENTS WITH SCREWPOSTS AND PICKETS.

The screwposts are 5 feet long.

The pickets are approximately 15 inches long, with a loop at the end.

If the ground is very soft, posts can be screwed in 2 feet deep.

The barbed wire should be twisted round the post through an eye and not simply laid in the eye; but in order to enable this to be done, the posts should be screwed in so that the loops face the enemy. The simplest form of entanglement is made by running a line of pickets at 6-foot intervals along the front and one or more lines of screwposts behind them, thus:

A	...	...	...	...	Pickets.
B	...	...	...	...	Posts.
C	...	...	...	...	Posts.

Line A represents the front line of pickets.

Lines B, C, etc., represent the line of posts.

The wiring is carried out as follows:

(*a*) Four horizontal strands on B.

(*b*) Diagonal front stays A1—top B1—A2—top B2, and so on.

(*c*) Two or three horizontal wires along front stays.

(*d*) Diagonal stay top C1—bottom B1—top C2—bottom B2, and so on.

(*e*) Diagonal stay bottom C1—top B1—bottom C2—top B2, and so on.

(*f*) Loose coils between lines B and C.

(*g*) Four horizontal wires on C line.

Care should be taken to carry out the work in this order. The diagonal staying as at (*d*) is not easy owing to the difficulty in attaching the wire to the bottom of the post; but if the lowest loop is used it is simplified.

Line after line can thus be erected one behind the other. The following has been found a simple procedure:

Lay out line with tracing tape.

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Each man to carry three posts and three pickets—lay them out on line.

Twelve men are divided into four parties—W, X, Y, Z. W1, X1, Y1, and Z1 each to carry a hard wood spindle which can be used for screwing in the posts and for carrying the barbed wire.

Having screwed in posts by parties, 1 and 2 of each party rolls out a coil superintended by 3, who attaches it to posts.

Party W starts on the bottom horizontal, X follows behind, and so on, one party after the other.

On completion, W and X parties work toward each other on front diagonal stay from each end; Y and Z work on diagonal stays, as at (*d*) and (*e*); Y goes ahead of Z, care being taken that the stays as at (*d*) keep ahead of those as at (*e*), otherwise some difficulty will be experienced.

The work will then be repeated. Much time will be saved if all the wire fastenings on the barbed wire coils are cut by daylight, the end of the wire being then attached to a piece of string and then uncoiled half a turn and recoiled on a piece of an old sandbag, the string being then made fast; the end of the wire can then be readily found in the dark.

The entanglement should be made entirely of barbed wire.

DRILL FOR PUTTING UP WIRE ENTANGLEMENTS.

The following is a drill for putting up a wire fence with a double apron. Each post has two side stays to obviate having to cut short lengths of wire for this purpose. The fence can be improved by adding horizontal wires along the apron. Angle iron pickets or screw pickets can be used. The principle of the drill is the same, whatever type of picket is used.

The party is divided into three squads—the long picket squad, the short picket squad, and the wiring squad. The long picket squad consists of two men, with one maul or sledge hammer if ordinary pickets are used, or two short pieces of wood for screwing the posts if screw pickets are available. The officer or noncommissioned officer in charge of the party goes with the long picket squad and shows them the line along which the fence is to run. The men then fix the pickets between 4 and 5 yards apart.

The short picket squad consists of four men, two working either side of the long pickets, and they fix the short pickets opposite the long pickets and two paces away from them.

The wiring squad is divided into four groups—A, B, C, D, of two men each. Group A starts by fixing the end of a coil of wire near

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the bottom of the first post. One man of this group then walks away with the coil, allowing it to unroll on a stick while the other forms loops in the wire, which he slips over each long picket as he comes to it, and pulls the wire sufficiently taut.

When group A has advanced about 20 yards, group B starts and fixes the second wire up from the ground on the long pickets in a similar way.

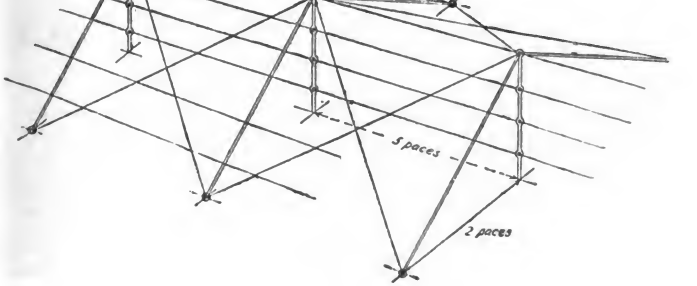
Groups C and D follow in their turn.

When all the wires on the long pickets are finished, groups A and B work on the apron on the enemy's side, and C and D on the rear side. A starts on a short picket and goes diagonally up to the next long picket—down to the short picket and so on. B works along the opposite diagonal. A's wire is shown by arrows on the sketch.

This completes the fence, but it can be improved by adding horizontal wires as shown in the sketch.

Each squad requires a party to keep it fed in the material; the strength of this party depends entirely on the distance away of the dump of material.

Total number of men required (irrespective of carrying parties): 1 noncommissioned officer, 14 men; time required, 15 minutes per 100 paces run; stores, 20 long pickets, 40 short pickets, 1,400 paces wire per 100 paces run.



Perspective view of wire fence.

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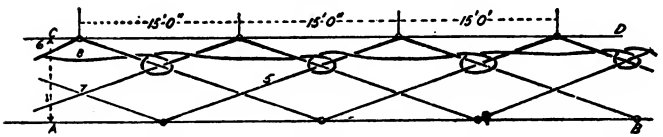
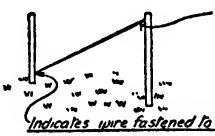
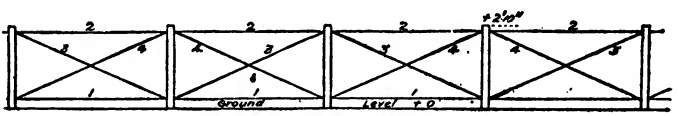
RAPID WIRE ENTANGLEMENT.

Not to Scale.



Plan.





Elevation of A.B. and of C.D.

ORDER OF WORK.

Two men place the posts on the ground (one on each side) with the wires as carriers.

Four men drive in the posts (two on each side).

Two men put on wire 1 of front row.

Two men put on wire 2 of front row.

Two men put on wire 3 of front row.

Two men put on wire 4 of front row.

Two men put on wire 5 (diagonal wire).

Two men put on wire 6 (diagonal wire).

Two men put on wire 7 (diagonal wire).

Two men put on wire 8 (looped wire).

Two men put on wire 1 of back row.

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4. Pairs Nos. 7 and 8 put on the diagonal wires between the big and small pickets. This completes the first part.

5. After a suitable distance, say 50 yards, has been done, the pairs as they finish return to the starting point and work as follows:

Pairs 1 and 2 lay down the trip wires.

Pairs 3 and 4 uncoil the loose barbed wire on the ground on either side well clear of the entanglement, 6 coils going to 20 yards.

Pairs 5 and 6 with large wood pickets lift the wire and toss it into the entanglement.

Pairs 7 and 8 spread it out and fasten the wire by taking a turn at intervals to the diagonals and fence wires.

6. It is necessary when the work requires to be done at any speed to have a carrying party carrying stores to dump at 50–100 yards' interval.

7. Stores required for 50 yards:

Barbed wire	coils..	25
Screw pickets, large	number..	25
Screw pickets, small	do....	52

N. B.—Care should be taken that spikes on top of the pickets are all pointing the same way, otherwise when passing the wire through loops the turn has sometimes to be made with running end and sometimes with standing part.

TABLE.

Pair.	First duty.	Second duty.
1	Screw in big screw pickets 6 feet apart..	Trip wire nearest enemy.
2	Screw in small screw pickets both sides..	Trip wire farthest from enemy.
3	Bottom fence wire marked "1" on diagram.	Uncoil loose wire side nearest enemy.
4	Second fence wire from bottom marked "2" on diagram.	Uncoil loose wire side farthest from enemy.
5	Third fence wire from bottom marked "3" on diagram.	Toss in loose wire uncoiled by third pair.
6	Top fence wire marked "4" on diagram will give pickets one complete turn.	Toss in loose wire uncoiled by fourth pair.
7	Diagonal wire side nearest enemy marked "5."	Fasten loose wire.
8	Diagonal wire side farthest from enemy marked "6."	Do.

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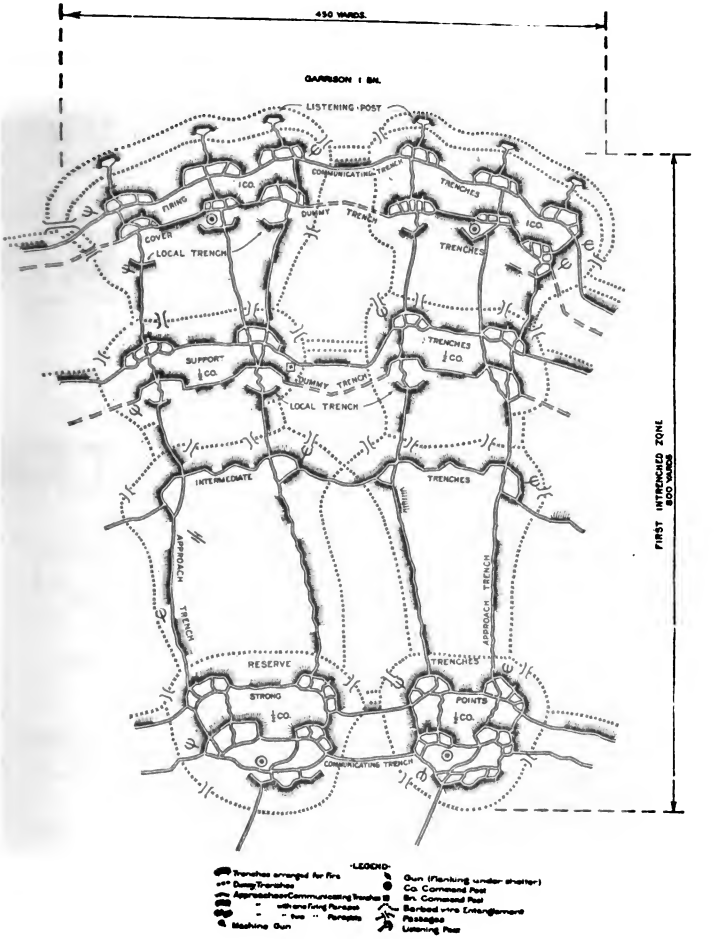

PLATE I.

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